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THE

COMPARATIVE ANATOMY

OF THE

DOMESTICATED ANIMALS

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DOMESTICATED ANIMALS

BY

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SECOND ENGLISH EDITION

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IN COMMEMORATION OF THE CENTENARY

OF THE

ROYAL VETERINARY COLLEGE, LONDON;

THE PARENT OF VETERINARY SCHOOLS IN ENGLISH-SPEAKING COUNTRIES.

AND IN MEMORY OF

CHARLES VIAL DE SAINT-BEL,

EQUERRY TO LOUIS XVI. OF FRANCE, PRINCIPAL OF THE LYONS ACADEMY,

PROFESSOR IN THE ROYAL VETERINARY SCHOOL OF THAT CITY,

AND

DEMONSTRATOR OF COMPARATIVE ANATOMY AT MONTPELLIER;

WHO, WHEN A REFUGEE FROM THE GREAT FRENCH REVOLUTION, WAS

CHIEFLY INSTRUMENTAL IN ESTABLISHING THE FIRST ENGLISH VETERINARY SCHOOL,

IN WHICH HE WAS THE FIRST TEACHER,

1791.

PREFACE TO THE SECOND ENGLISH EDITION.

SINCE the translation of this work into English, seventeen years ago, it has been several times reprinted, the last occasion being in 1889. Circumstances had, however, for some time indicated that there was need for a revision of the work in order to bring it up to the requirements of the present day, and the issue of a fourth French edition last year was considered a favourable opportunity for undertaking the task.

In preparing this second edition, the necessities of advancing veterinary education in the English-speaking schools was kept in view, and this entailed considerable amendments, alterations, and additions, in order to adapt it more perfectly to the conditions it should fulfil as a text-book and standard work of reference on the subject.

The high esteem in which the first edition has been held for so many years in this country, in our Colonies, and in the United States of America, amply testifies to the value of the work; and in this new edition everything has been done to render it still more comprehensive, complete, and useful. The anatomy of the Ass, Mule, and Rabbit has been added, as well as that of the Camel—that animal being utilized not only in our army in different parts of the world, but also in some of our Colonies. The number of illustrations has been increased by more than one hundred and thirty, the pages have been enlarged, and the letterpress so modified as to make reading and reference much easier.

A copious index—there is none in the French edition—has also been added, with the view of enhancing the usefulness of the book as a work of reference for students and practitioners.

With these alterations, additions, and modifications, I trust the work may continue to be accepted as in every way worthy of the position accorded to it as the best on the subject.

The editorial remarks—for which, as well as for the translation, I assume the entire responsibility—are included in brackets, as in the first edition.

GEORGE FLEMING.

LONDON,
April, 1891.

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THE COMPARATIVE ANATOMY

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DOMESTICATED ANIMALS.

GENERAL CONSIDERATIONS.

DEFINITION AND DIVISIONS OF ANATOMY.

Anatomy is the science of organization; it studies the structure of animals when these are dead. It comprises two grand divisions—*physiological anatomy*, which describes healthy organs, and *pathological anatomy*, the object of which is the description of diseased organs.

Physiological anatomy, which alone is treated of in this book, in its turn embraces—

1. *General anatomy*, which is occupied with similar substances or tissues of the animal body, with regard to their texture, and their physical, chemical, and physiological properties, irrespective of the organs in which these tissues are found. The particular study of the anatomical elements entering into the composition of the tissues, is named *histology*. Histology necessarily requires the aid of the microscope.

2. *Descriptive anatomy*, which studies the situation, form, and relations of organs, as well as the relative arrangement of the various tissues composing them, with the exception of the structure and properties of these tissues.

If this study be devoted to a single species, it is designated *special anatomy*. Example: human anatomy, or *anthropotomy;* the anatomy of the Horse, or *hippotomy*.

When descriptive anatomy embraces the study of the organization of the entire animal kingdom, and examines the *differences* which characterize the same organ or the same series of organs in each class, family, genus, or species, it is named *comparative anatomy*. Restricted to the domesticated animals, this study constitutes *veterinary anatomy*.

Philosophical or *transcendental* anatomy differs from comparative anatomy, in that it indicates the *analogies* of organs or apparatus, rather than their differences, in order to exhibit as clearly as possible the general laws of organization.

Finally, if descriptive anatomy be limited to denoting the relations existing between the various organs of a region, particularly with a view to the performance of operations and the diagnosis of external diseases, it takes the names of *topographical*, *regional*, or *surgical anatomy*.

Enumeration and Classification of the Species of Domesticated Animals.

The object of this book is the study of *veterinary anatomy*. The animals of which it treats belong to the Mammiferous class and to that of Birds.

The domesticated Mammals of our climates have their representatives in a large number of orders. Thus, we find among them—

1. Of the Carnivora, the *Dog* and *Cat;*
2. A Rodent, the *Rabbit;*
3. A Pachyderm, the *Pig;*
4. Of Solipeds, the *Horse* and *Ass;* the produce of the Male Ass with the mare, *i.e.* the *Mule*, and that of the Horse with the Female Ass, known by the name of *Hinny;*
5. Of Ruminants, the *Ox*, *Sheep*, and *Goat.*

With regard to Poultry, they range themselves—

1. In the Gallinaceous or Columba order, the genera to which the *Common Fowl*, *Guinea Fowl*, *Turkey*, and *Pigeon* belong;

In the order of Palmipeds, the *Goose* and *Duck.*

Girard has proposed a special classification for the domesticated Mammals, based upon the number of digits terminating each of their limbs, and has defined four categories: the first comprises the Horse, Ass, Mule, and Hinny, which take the name of *monodactyles*, because their digital region is composed of a single digit; in the second, under the denomination of *didactyles* or *bisulcate* animals, those with two digits, such as the Ox, Sheep, and Goat; in the third, or *regular tetradactyles*, is found the Pig, each of whose limbs has four digits; lastly, the Dog and Cat, which most frequently have four digits on the posterior members and five on the anterior ones, and form the class of *irregular tetradactyles.*

This nomenclature will not be followed here, as it is opposed to the general laws of organization. Philosophical anatomy has, in fact, demonstrated that there are really no true monodactyles, didactyles, etc.; all are materially or virtually pentadactyles. It is therefore considered better to keep to the classification established by zoologists, because it prevents confusion in scientific language.

The regimen and habits of the domesticated animals bring about differences in their organization; these appear very great at first sight, though in reality they are not so marked as they seem.

In order to study the descriptive anatomy of all these animals, we will not pass them in review, one after another, giving for each the description of every organ; but shall take a type, which will most frequently be the Horse, implicitly compared with man, and briefly compare all the others with it. In this comparison, the animals will be generally classed according to their domestic value; though exceptions will be made to the rule which has been instituted by our predecessors, whenever any advantage in point of concision or perspicuity is likely to be obtained.

General Ideas of the Organization of Animals.

Order followed in studying the Various Apparatuses.

The bodies of animals contain fluid and solid organic matters, as well as gases and some mineral substances.

Organic Fluids.—The fluids are very abundant in the animal economy;

not only do they fill certain vessels constructed for them, but they also impregnate all the solid parts of the body. Their importance is very great, for without them the organic solids would perish; an element deprived of humidity is *ipso facto* deprived of life.

These fluids vary in their nature and composition. Apart from those that the solids imbibe, there is not one which is completely amorphous. In the midst of a liquid holding organized matter in solution, there are always formed elements which will be referred to hereafter. Examples: the blood and lymph.

ORGANIC SOLIDS.—In studying the organic solids, we will proceed from the simple to the complex.

Solid organized matter is amorphous—as in the hyaline substance of cartilage and the fundamental substance of bone tissue, or it assumes the form of more or less voluminous particles in every instance invisible to the naked eye, and to which the name of *anatomical elements* has been given. They may be reduced to three principal: the granule, the cell, and the fibre.

Granules.—These are the smallest known elements. They may be held in suspension in animal fluids, remain free among the other elements, or be enclosed in the interior of cells. Their nature is not always the same: they are *proteic*, *fatty*, or *pigmentary*. The *pigmentary* granules are of a brown colour.

Cells.—The cell is pre-eminently the anatomical element.

Theoretically, the cell is a microscopic mass of a nitrogenous substance, viscid (*protoplasm* or *sarcode*), uniformly transparent, or slightly granular. Frequently in the midst of this *protoplasm* there is perceived a nucleus provided with a nucleolus, and at its periphery an enveloping membrane.

The cell lives like an entire organism: it feeds, grows, multiplies, absorbs, secretes, moves, etc. It behaves like a complete animal, though it be a microscopic one.

The form of the cell, as well as its volume and nature, vary. It has therefore received various names.

There are round, polyhedral, fusiform, conical, stellate, and other shaped cells. Some have a diameter of 1–12000th part of an inch, while others are 1–2000th part. Cells multiply in various ways: 1st, by the division of the nucleus and segmentation of the protoplasm in the interior of the enveloping membrane (*endogenous multiplication*); 2nd, by constriction, then division of the nucleus, protoplasm, and enveloping membrane (*fissiparous multiplication*); 3rd, by a kind of bulging or swelling of the enveloping membrane, and constriction and separation of the enlargement thus formed (*gemmation*).

A large number of cells only temporarily remain in this condition. In consequence of modifications that cannot be referred to here, they are converted into fibrillæ or other elements, in which it is difficult to recognize the primordial element.

Others maintain the cellular form: then they develop, live, and die in several ways. Sometimes they are worn by the contact of foreign bodies, as on the surface of the skin; sometimes they become liquefied, as in some glands; and at other times they undergo fatty degeneration, which gradually brings about their complete destruction.

The permanent cells are—

1. *Hæmaties* or *red corpuscles*, which are found in a state of suspension in the blood; they are round and discoid in Mammalia, with the exception of the Camel and Llama, in which they are elliptical, as well as in Birds, Reptiles, and

the majority of Fishes. These cells have an envelope, but they do not have a nucleus in Mammalia ;

2. *Leucocytes*, *white corpuscles*, or *lymph cells*, which float in the blood, lymph, chyle, and the connective tissue interspaces. These cells are susceptible of amæboid movements, and their fundamental form is spherical ; though they are often irregular in shape, owing to the contractile prolongations they throw out, called *pseupodes*. They may have one or more irregular nuclei ;

3. *Connective cells*, which are flat, nucleated, and irregular ; they are applied to the fasciculi of connective fibres ;

4. *Adipose cells*, lying in the connective tissue and filled with fat, which has pushed the protoplasm and nucleus towards the envelope ;

5. *Medullary cells*, with a budding nucleus or multiple nuclei (myeloplaxes and medullo-cells), forming the principal elements of the marrow of bones ;

6. *Cartilage cells*, which have no envelope, and which, single or associated with a variable intermediate substance, form cartilages ;

7. *Bone cells*, lodged in a space remarkable for its elliptical shape and the numerous prolongations on its margin. The cells are nucleated, have no envelope, and secrete the fundamental solid substance of the bony tissue ;

8. *Contractile cells*, which constitute the basis of muscular tissue. They are fusiform and nucleated ;

9. *Nerve cells*, met with in the cerebro-spinal centres and the ganglia of the cerebro-spinal and sympathetic systems. They are provided with one, two, or more prolongations called *poles* ; hence they are *uni-*, *bi-*, or *multipolar*.

10. *Epithelial cells*, found on the surface of tegumentary membranes, or laid over the interior of more or less diverticulated cavities (glandular cavities or glands). The epithelial element is lamellar or polyhedric, cylindrical, calciform, vibratile, etc.

11. *Endothelial cells*, always lamellar, and lining serous cavities and vascular canals.

Fibres.—A fibre is an elongated element of variable dimensions and composition. Thus, it may be very fine (*connective fibre*), or thick and limited by two borders more or less apart (*muscular fibre*) ; it is homogeneous throughout (*elastic fibre*), or has a contents and a distinct envelope (*nerve fibre*). The vitality of fibres is not comparable with that of cells. Once formed, they are only nourished, for it is not yet definitely ascertained whether they can multiply.

In the animal economy there are four kinds of fibres—

1. *Connective fibre*, an extremely fine element, but in which, nevertheless, two borders can be distinguished if it be examined by a power of from 800 to 1000 diameters. The fibres form fasciculi in the connective tissue, or are distributed in the midst of a fundamental substance—as in the fibro-cartilages. The connective fibre constitutes the most solid organs of the animal economy—the ligaments, tendons, etc.

2. *Elastic fibre*, found closely packed in certain organs, such as the cervical ligament and abdominal tunic, or forming a network in the midst of connective tissue ; it is even found in the framework of bones.

3. *Muscular fibre*, smooth or striped (striated), which has the property of contracting under the influence of stimuli. Smooth (or unstriped), is found in a large number of viscera ; striped is more especially in the domain of the locomotory apparatus.

4. *Nerve fibre*, very remarkable for its continuous axis-cylinder. It is found in the nerve centres, cerebro-spinal nerves, and great sympathetic system.

Inorganic Substances.—These substances (*gases* and *mineral matters*) are usually found in solution in the animal fluids. Their presence is indispensable in the constitution of the living body.

Sometimes the mineral matters are solid, amorphous, or crystallized. In this condition they are rarely met with in healthy organs (*internal ear*); but they are frequently found in diseased ones.

Tissues.—The anatomical elements, by being grouped in different manners, form tissues. Some tissues are constituted by one kind of element; these are *simple tissues*—for example, epithelial tissue. But the larger number are formed by a combination of several different elements; these are *composite tissues*—for example, nerve tissue.

The anatomical, physico-chemical, and physiological characters of the tissues, are repeated, it need scarcely be remarked, in the anatomical, physico-chemical, and physiological properties of the elements which enter into their composition.

Only four simple types of fundamental tissue are described, and which are based on the morphological, chemical, and physiological characters of the constituent elements—

1. In the first place, there are to be noted the *tissues of connective substance* or framework, comprising the varieties of *connective tissue*, *fibrous tissue*, *elastic tissue*, *cartilaginous tissue*, and *bone tissue*.

2. Then there are the *cellular tissues*, formed entirely of persistent cells; they are the *epithelial tissue proper*, and the *glandular tissue*.

The cells of the epithelial tissue are differently arranged. If they are disposed in a single layer, they constitute a *simple epithelium*; but if superposed so as to form two or more layers, then it is a *stratified epithelium*. According to the form of the superficial layer of cells, the epithelium is *polyhedric*, *pavement*, *cylindrical*, *spherical*, or *calciform*. In certain parts the superficial cells are furnished with vibratile cilia, and the epithelium is then called *vibratile* (or *ciliated*).

3. The third type is represented by the *muscular tissue*, the agent of movement, which is divided into striated and non-striated muscle.

4. Lastly, there is the nerve tissue, which is present under two aspects—*white substance* and *grey substance*. The first is formed entirely of nerve fibres and a supporting tissue or *neuroglia*; the second by fibres and nerve cells united by neuroglia. The grey substance belongs to the most important portions of the nervous system—the brain, spinal cord, and ganglia, where it co-exists with the white substance. The latter entirely constitutes the peripheral ramifications of the nervous system.

Organs.—The term "organ" is given to any portion of the body having a determinate form and a function to fulfil. A bone, a muscle, the stomach, the liver, and the brain, are organs.

General Arrangement of the Organs and Apparatus.—All animal organs are enclosed between two membranes named *limitary* or *tegumentary membranes*, which are continuous with one another at the margin of the natural openings. These are the *skin* and the *mucous membranes*, in the composition of which are included a layer of connective tissue and an epithelium

Organs protected by these membranes are *solid* or *hollow*.

Among the first, a certain number act as supports: such are the organs formed by the connective tissue, and particularly the *cartilages* and *bones*.

Others are destined to produce movements: these are the muscles. The action of the muscles is communicated directly to the organs that are to be moved, or it is transmitted through the medium of other organs, such as the *tendons* and the *aponeuroses*.

The *central nervous organs*—the *nerves* properly so called—belong to this group of solid organs. The activity of muscles and the sensibility of limitary membranes are due to them.

With regard to the hollow organs, they are everywhere formed by an envelope of smooth (or unstriped) muscular tissue, lined by an internal tegumentary or mucous membrane. Examples: the bladder and stomach. There must also be included the vessels formed by elastic and contractile membranes arranged as canals, in which the blood and lymph circulate; the glands, and, lastly, the serous membranes which line the interior of the splanchnic cavities, cover the surface of the organs contained in them, and the inner face of the articulations and synovial sheaths.

It is remarkable that, in the trunk, the bones form two superposed cylinders, one of which lodges the organs of circulation, digestion, and respiration, and the other the central nervous system (*neural* and *hæmal cylinder*).

APPARATUS.—Organs are very numerous in the animal economy, and in order to study them profitably it is necessary to classify them in a methodical manner, according to their physiological affinities. Consequently, there have been collected into a single category all those organs which are destined to achieve the same physiological finality, and to such a group has been given the name of *apparatus*.

Bichat has grouped the apparatuses according to the ultimate object of their functions, and has thus formed two great categories: one, comprising the apparatuses which maintain the individual (*apparatuses of nutrition and relation*); the other, the apparatus destined for the preservation of the species (*apparatus of generation*).

We will describe these apparatuses in the following order:—

1. *Locomotory Apparatus*;
2. *Digestive Apparatus*;
3. *Respiratory Apparatus*;
4. *Urinary Depurative Apparatus*;
5. *Circulatory Apparatus*;
6. *Innervatory Apparatus*;
7. *Sensory Apparatus*;
8. *Generative Apparatus*.

This description will be terminated by a brief notice of the *evolution of the fœtus, and its appendages*.

BOOK I.

Locomotory Apparatus.

The *locomotory apparatus* is composed of all those organs which minister to the movements an animal may execute. It is certainly one of the most important in the economy, from the number and size of the pieces which enter into its formation, and by the necessary co-operation it affords the majority of the other apparatuses in the performance of the physiological acts allotted to them.

It is constituted of two kinds of organs—the *bones* and *muscles*. The *bones*, hard and resisting, stony in appearance, are really inert levers, joined by firm and movable *articulations*, which permit their playing upon each other with the greatest facility, at the same time maintaining them in their relative positions. The *muscles*, grouped around the bones and attached to them, are soft organs which possess the property of contraction, under certain determinate conditions, and of involving in that movement the bones to which they are fixed by their extremities. The bones are altogether passive in their motion, while the muscles are really the active organs of locomotion—the power intended to move the bony levers.

We will study, successively—

1. The bones, a particular branch of descriptive anatomy which has received the name of *Osteology*;
2. The articulations, or *Arthrology*;
3. The muscles, or *Myology*.

FIRST SECTION.

The Bones.

CHAPTER I.

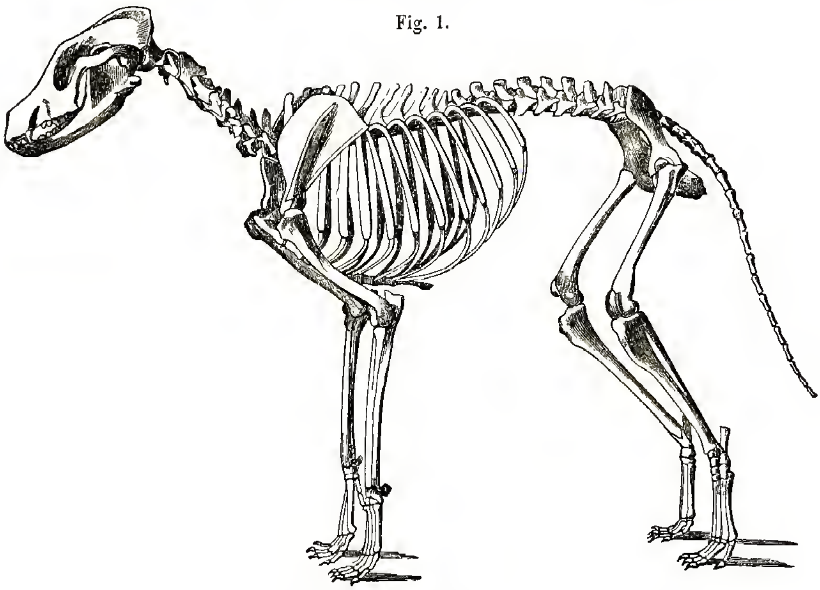
THE BONES IN GENERAL.

Bones, properly speaking, are only to be found in vertebrate animals, and constitute their principal zoological character. In the animal body they form an internal framework which consolidates the entire edifice, and gives it its general form and dimensions. It is advantageous, before commencing a particular description of each bone, to survey them in a general manner. This study comprises: 1. The description of the *skeleton*; 2. A summary indication of the *general principles* which should be known, in order to comprehend the details of the special descriptions.

Article I.—The Skeleton.

The whole of the bones, considered in their natural relations to each other, constitute the *skeleton*. In order to prepare the skeleton of any animal, it is

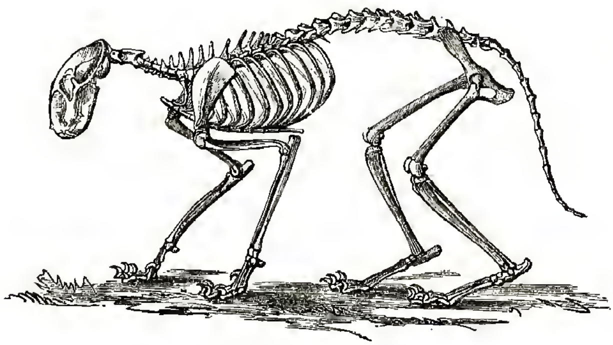
Fig. 1.



SKELETON OF THE DOG.

sufficient to free it from the soft parts surrounding it. The skeleton should be designated *natural*, if in this operation the ligaments that naturally join the

Fig. 2.



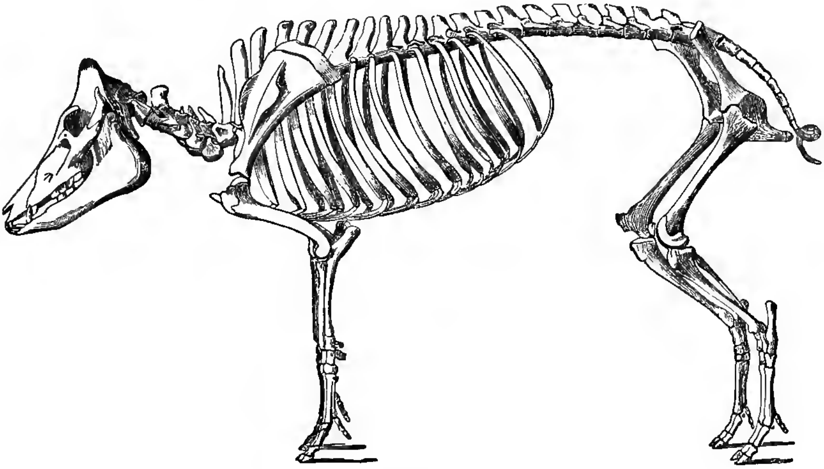
SKELETON OF THE CAT.

various pieces together are allowed to remain; and *artificial* if, after these ligaments have been destroyed, it is necessary to replace them by materials foreign to the organization, such as iron or brass wire.

The skeleton is divided into *trunk* and *limbs*.

1. The trunk offers for consideration, in the middle line, the *spine* or *vertebral column*—a flexible stalk measuring the entire length of the animal, and composed of a series of distinct pieces articulated one behind the other. Anteriorly, this stalk supports the *head*—a pyramidal mass which results from the assemblage of a large number of bones. On each side of the middle portion of

Fig. 3.

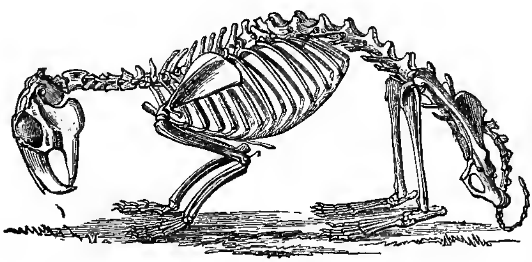


SKELETON OF THE PIG.

the spine, there are detached bony arches which have received the name of *ribs*, and which rest, directly or indirectly, by their inferior extremities, on a single bone called the *sternum*. These bony arches in this way circumscribe the *thorax*—a spacious cavity destined for the reception of the principal organs of respiration and circulation.

2. The *limbs*, four in number—two *anterior* and two *posterior*—are the ap-

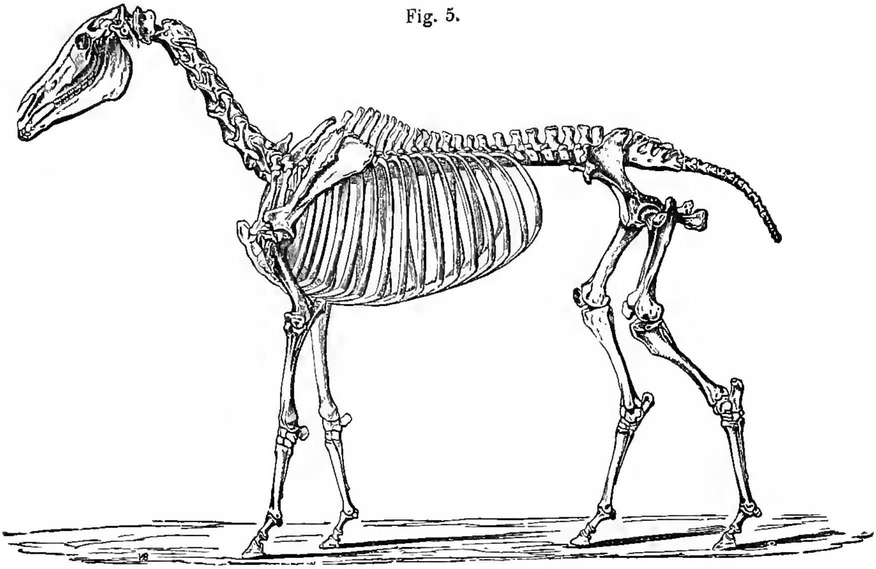
Fig. 4.



SKELETON OF THE RABBIT.

pendages which support the trunk of the domestic Mammals. They are usually distinguished as *anterior* and posterior (or *fore* and *hind*), but it will be more convenient to name them according to their relations, as *thoracic* (or *pectoral*) and *abdominal* limbs. Each represents a column divided into several rays resting upon one another, and generally forming more or less open angles. The *anterior limbs* are each divisible into four principal regions : the *shoulder*, applied against the front part of the thorax ; the *arm*, which succeeds the shoulder ; and the *fore-*

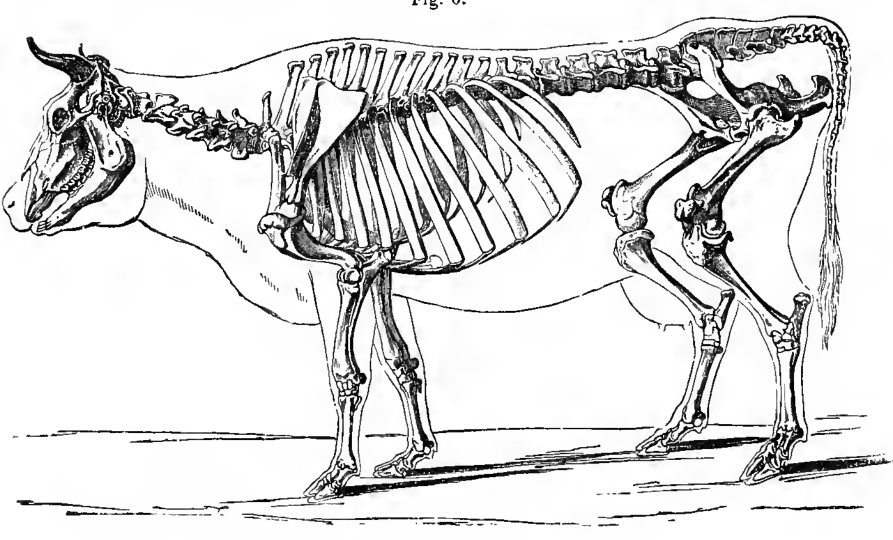
Fig. 5.



SKELETON OF THE HORSE.

arm, and *foot*. The *posterior limbs* also comprise four regions : the *haunch* or *pelvis*, which articulates with the posterior part of the spine ; and the *thigh*, *leg*, and *posterior foot*.

Fig. 6.

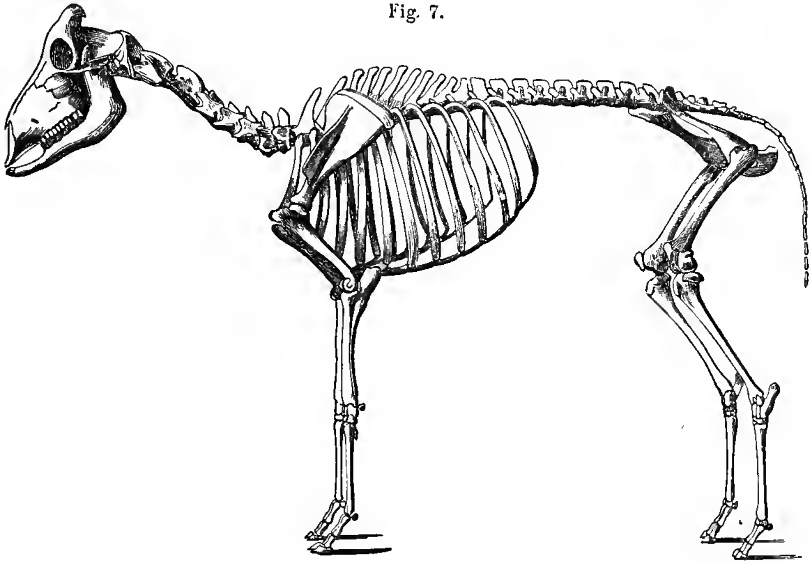


SKELETON OF THE COW.

In Birds, the posterior limbs alone assume the function of columns of support. The thoracic limbs, formed for flight, constitute the *wings*.

The number of bones entering into the composition of the skeleton of the principal domesticated animals, arrived at the adult period of life, varies according to the species. They are apportioned to the regions of the trunk and limbs just mentioned, in the manner indicated in the following table :—

Fig. 7.



SKELETON OF THE SHEEP.

Designation.		Solipeds.[1]	Ruminants.	Pig.	Dog.[2]
Vertebral Column[3]		48	45	50	46
Head[4]		28	28	29	28
Thorax		37	27	29	27
Shoulder	Double regions	1— 2	1— 2	1— 2	1— 2
Arm	Double regions	1— 2	1— 2	1— 2	1— 2
Forearm	Double regions	2— 2	2— 4	2— 4	2— 4
Fore foot	Double regions	16—32	20—40	36—72	36—72
Pelvis	Double regions	1— 2	1— 2	1— 2	1— 2
Thigh	Double regions	1— 2	1— 2	1— 2	1— 2
Leg	Double regions	3— 6	3— 6	3— 6	3— 6
Hind foot	Double regions	15—30	19—38	36—72	32—64
Totals		191	196	270	255

Article II.—General Principles applicable to the Study of all the Bones.

The description of a bone comprises its *name*, *situation*, *shape*, internal *conformation*, *structure*, and mode of *development*.

[1] One lumbar vertebra less is found in the Ass, and sometimes also in the Mule.

[2] The os penis has not been included.

[3] The sacrum is reckoned as a single bone, and the number of coccygeal vertebræ at an average of 16 for the Horse, 18 for the Ox, 22 for the Pig, and 18 for the Dog.

[4] The os hyoïdes is reckoned as a single bone.

Name.

The nomenclature of osteology does not rest on any basis capable of conferring upon it a methodic form. Consequently, we find bones which derive their name from their shape (example: the fibula); others from their resemblance

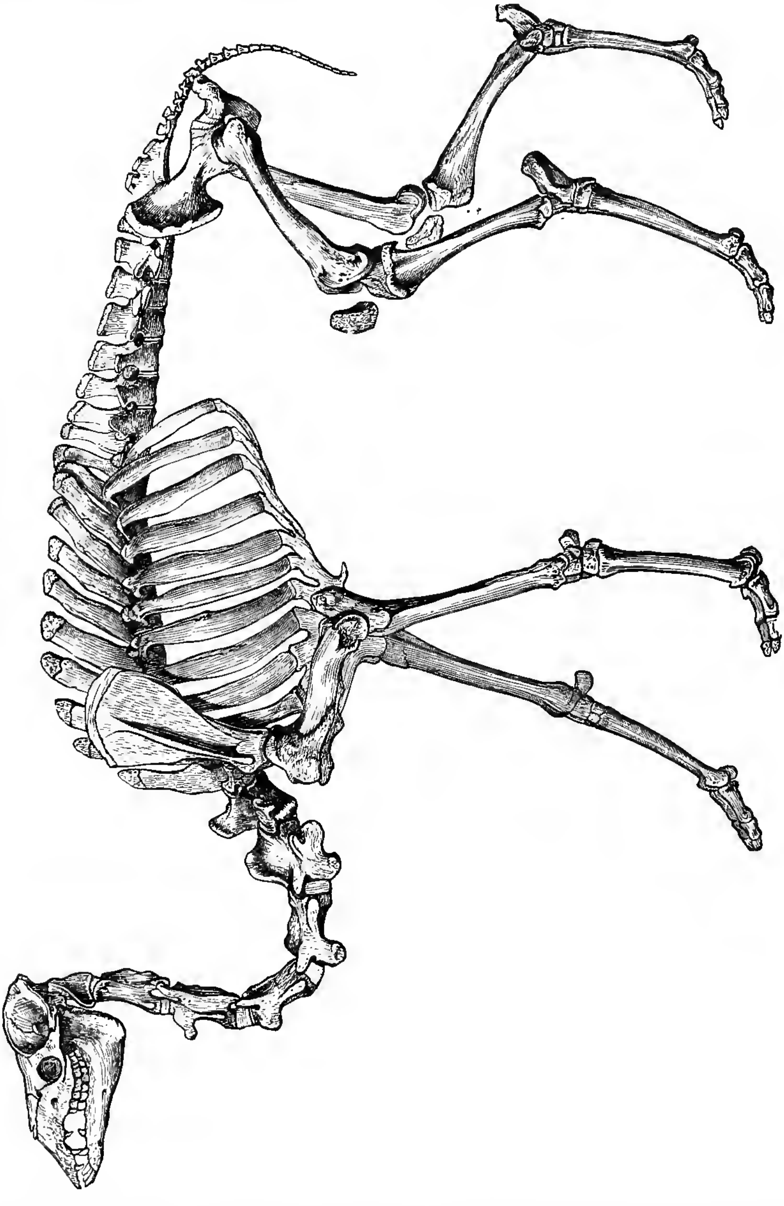


Fig. 8. SKELETON OF THE CAMEL.

to known objects (the tibia and vomer). Some owe it to their position (the frontal bone), or their uses (the axis and parietal bones). Several attempts have been made to submit the nomenclature of the bones to more precise and uniform rules, but the new designations proposed have not been sanctioned by custom.

Situation.

The situation of a bone should be viewed in two ways: 1st, *Relative to the median plane of the body;* 2nd, *Relative to the other portions of the skeleton.*

A. *Situation relative to the median plane of the body.*—The designation of *median plane*, improperly *median line*, is given to an imaginary vertical plane passing through the middle of the skeleton, which it divides from before to behind, into two equal portions. The bones may be situated on the median plane, in which case there is only one of each kind, and they are called *single;* they are also named *symmetrical bones*, because the median plane divides them into equal lateral halves exactly alike.[1] The bones disposed in a double and regular manner on the sides of the median plane bear, for this reason, the name of *pair bones;* they are also called *asymmetrical bones*, because their form does not admit of their being divided, in any sense, into two similar portions. On the contrary, a bone of this kind always offers the most perfect symmetry with its fellow on the opposite side.[2]

B. *Relative situation to the other parts of the skeleton.*—To indicate the situation of a bone, considered from this point of view, is to make known the place it occupies in the region to which it belongs, and the connections it may have with adjoining regions. Thus, the radius is situated in front of the ulna, between the arm-bone and the carpus.

Direction.

This is *absolute* or *relative.*

A. The *absolute direction* is related to the axes of the bones themselves. Thus it is that a bone may be *rectilinear*, *curvilinear*, or *twisted.*

B. The *relative direction* is determined by the relation to the fictitious planes established around or in the interior of the skeleton, or with regard to the neighbouring bones. For example, a bone is vertical, horizontal, or oblique. In the latter case it may be downwards and backwards, or in the reverse direction. Example: the scapula is placed obliquely downwards and forwards.

Shape of the Bones.

FORM.—This is also *absolute* or *relative.*

A. *Absolute Form.*—The absolute form of a bone is that which it owes to the relations existing between its three dimensions—length, width, and thickness. *a.* A bone in which one of its dimensions much exceeds those of the other two is a *long bone* (example: the femur), provided it be hollowed out internally by an elongated space—the medullary canal. Long bones belong exclusively to the limbs. In the animal economy there are found bones which resemble them in their dimensions, but they have no medullary canal (example: the ribs). These differ essentially from the true long bones, and are also distinguished from them by the appellation of *elongated bones.* *b.* A bone that offers two dimensions much more developed than the third, is a *flat* or *wide bone* (example: the parietal bone). The bones of this category, destitute of a medullary cavity, are

[1] Instances have been recorded of asymmetry in single bones. Lesbre has seen the sixth cervical vertebra of the Horse tricuspid on one side and bicuspid on the other, and a last dorsal vertebra with one of its transverse processes having the characters of the lumbar vertebræ.

[2] But there might be slight differences in weight, torsion, etc. In Man there is nearly always a difference between the right and the left side.

met with in the head and the upper regions of the limbs. *c.* A bone which offers nearly the same development in all its dimensions, is called a *short bone* (example: the astragalus). Destitute, like the preceding, of a medullary canal, the short bones are found in the spine and some regions of the limbs.

B. *Relative Form.*—To make known the relative form of a bone, is to indicate the greater or less exact resemblance it may bear to geometrical figures, or to familiar objects. Thus, the scapula is a bone of a triangular shape.

Regions of the Bones.—When describing the eminences and external cavities of bones, it is essential not to allude to them casually by passing indifferently from one to another. To avoid the difficulties resulting from the application of such an irrational system, it is necessary to divide the bone to be studied into several regions, in which external peculiarities can be examined successively, as they present themselves. The general course to be followed in order to learn the regions of a long, a flat, and a short bone, is as follows:—

a. A long bone is always divided into three parts—*a body* and *two extremities.* The *body* or *middle* portion, or *diaphysis*, is the narrowest part of the bone. In shape it is a geometrical solid, inclining somewhat to that of a very long prism. On the body of a bone, therefore, there are studied as many faces and planes, angles or borders, as on the prism it represents.

The *extremities*, or *epiphyses*, are more or less considerable enlargements, formed primarily by a special bony nucleus, and offering articular surfaces, as well as surfaces for muscular or ligamentous insertion.

b. A flat bone must necessarily have two *faces*, and *borders* and *angles.*

c. A short bone has more or less *faces*, and plane or salient angles which are often ignored, because of their trifling importance.

External Peculiarities of Bones.—These markedly attract the attention, because they modify the general shape of bones, and singularly assist in distinguishing one bone from another. These peculiarities, which are real distinctive features that permit their description to be precisely established, are always either eminences or cavities, according to their different uses.

A. *Eminences.*—The eminences that stand out in relief from the surfaces of bones, are divided into two different categories. One class concurs in the formation of the articulations which join the bones to each other; they are named *articular eminences*, in which, again, are distinguished *diarthrodial* and *synarthrodial eminences*, according as they belong to movable or immovable articulations. The others, usually destined for the insertion of ligaments and muscles, are called *non-articular eminences* or *eminences of insertion.*

(The term *imprint* is also used in anatomy, and signifies a collection of small rugged eminences which make the surface of the bone uneven and rough. There are muscular, tendinous, ligamentous, and aponeurotic imprints, according as they give attachment to muscles, tendons, ligaments, or aponeuroses.)

a. The *synarthrodial eminences* are always indentations more or less deep and finely cut, which stud the border of large bones.

b. The *diarthrodial eminences* are voluminous, smooth, and in a fresh state covered with cartilage. They are named heads and condyles: *heads*, when they describe the segment of a sphere (head of the femur, head of the humerus); *condyles*, when they represent an ovoid segment cut parallel to its larger axis (condyles of the femur).

c. The *non-articular eminences* receive various names. If they are voluminous and much detached from the bone, they are called *processes* or *apophyses.*

Apophyses receive qualificatives derived from the analogies perceived between them and known objects (examples: the styloid, clinoid, coronoid, and coracoid processes). The appellations of *protuberances* and *tuberosities* are given to non-articular eminences when they are large and round, and slightly detached. Lastly, they are named *lines*, *crests*, and *ridges*, when they are narrow and very long.

The processes are sometimes epiphysary in early life, and formed by a special nucleus.

B. *Cavities.*—The cavities of bones have also been divided into *articular*, *diarthrodial* or *synarthrodial*, and *non-articular cavities.*

a. The *diarthrodial cavities* correspond to the eminences of the same name in the bony joints. They take the designation of *glenoid cavities* when they are oval and shallow, and *cotyloid cavities* when they are deeply excavated, like a basin or the cup of an acorn (examples: the glenoid cavity of the scapula, and the cotyloid cavity of the coxà). The *synarthrodial cavities* fit into the dentations opposed to them.

b. The non-articular cavities serve either for ligamentous or muscular insertion, or for the passage of vessels, nerves, tendons, etc.

They are termed *channels* or *furrows*, when they are wide, deep, and smooth; *grooves*, when they are long, narrow, and smooth at the bottom; and *fissures*, when they are narrow and rugged. *Digital impressions* is the name given to those excavations in bones which look as if produced by the pressure of the finger. The *fossæ*, *sinuses*, *cells*, and *notches* are also non-articular cavities of bones. The sinuses and cells are formed by open spaces in the interior of bones; notches, by cavities excavated on their margins.

When a cavity passes quite through a bone, it is termed a *foramen*. If this foramen has a certain length, it is designated a *conduit* or *canal*. *Fissures* are long, narrow openings; *hiatus* is the term applied to a wide opening with an irregular outline.

In order to aid the memory, the external peculiarities of bones are grouped in the following synoptical table:—

- A. Eminences.
  - Articulars.
    - Synarthrodials. Dentations.
    - Diarthrodials. Heads. Condyles.
  - Non-Articulars.
    - Apophyses or processes. Styloids. Clinoids. Coronoids. Coracoids. Mastoids.
    - Protuberances.
    - Tuberosities.
    - Lines.
    - Crests.
- B. Cavities.
  - Articulars.
    - Synarthrodials. Fissures. Dentations.
    - Diarthrodials. Glenoids. Cotyloids.
  - Non-Articulars.
    - Channels.
    - Furrows.
    - Grooves.
    - Digital impressions.
    - Fossæ.
    - Sinuses.
    - Cells.
    - Notches.
    - Foraminæ.
    - Canals.
    - Ducts.
    - Slits.
    - Hiatuses.

Internal Conformation of Bones.

Sections made in various directions through the substance of bones, show that their internal conformation varies, according as they belong to the category of long, flat, or short bones. The diaphysis of long bones is hollowed out into a large fusiform cavity—the *medullary canal.* This canal is absent in the flat and short bones, and is replaced by irregular cavities which communicate with each other, called *medullary spaces.* Its walls are formed by a very dense bony tissue, the pores of which are scarcely visible to the naked eye, and which is called the *compact substance.* The extremities of long bones are surrounded by a thin layer of compact substance, while the remainder of their mass is constituted by the *spongy substance*—bony tissue channeled into medullary spaces. (*Reticulated* bony tissue is but another form of spongy substance, the only difference between the two consisting in the cells or meshes of the first being formed of intercrossed osseous *fibres*, while those of the second are formed of *lamellæ.*) The medullary canal, and areolæ of the spongy tissue, are filled by the *marrow* (or *medulla*).

The flat bones are constituted by a layer of spongy tissue placed between two plates of compact substance. (In the flat bones of the cranium, the two layers of compact tissue are termed the *vitreous tables*, while the cells of the spongy tissue are designated *diploë.*) In certain points of their extent, the spongy substance disappears, and then the bone is composed of a single lamina of compact tissue.

The short bones have a nucleus of spongy substance, enveloped in a layer, more or less thick, of compact tissue.

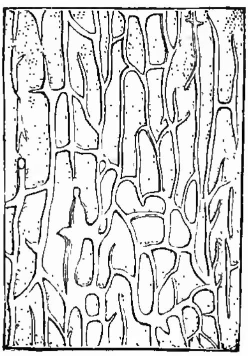
The compact substance of the bones, being very resisting, is found in all those situations which have to sustain violent efforts. The spongy substance is very light when compared with its volume, and is met with in the wider portions of the bones, to which it affords increased size without adding sensibly to their weight.

Structure of Bones.

Bones are formed of a *proper tissue*, covered externally by a particular membrane—the *periosteum*, and occupied internally by the *medulla*, *vessels*, and *nerves*.

A. *Proper tissue.*—The elements of the proper tissue of bone are always and everywhere the same ; the texture alone is modified in the compact and spongy substance.

Fig. 9.



VERTICAL SECTION OF BONE, showing the network of Haversian canals.

Everywhere the bone tissue is composed of a fundamental substance, which is amorphous or slightly granular, white, and more or less opaque, according to the thickness it offers. This fundamental substance is penetrated by an infinite number of vascular canaliculi (*bone cavities*), with prolongations (*bone canaliculi*), which contain cells (*bone cells*). The cavities and their contents are named *osseous corpuscles* or *osteoplasts.* In a dried plate of bone, the corpuscles appear dark when viewed by reflected light, white and shining by direct light.

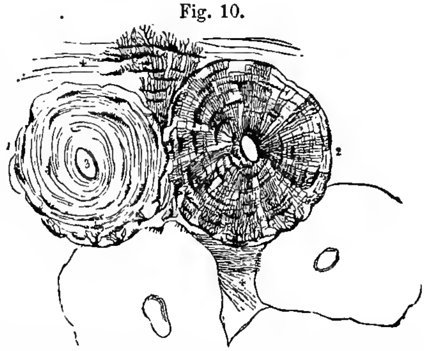
In the spongy tissue, the bone corpuscles, anastomosing by the ends of their canaliculi, are distributed throughout the lamellæ of fundamental substance, which is intercrossed in such a way as to circumscribe the numerous medullary spaces.

In the compact tissue, the corpuscles are regularly distributed in the substance of the bony lamellæ, which are arranged in concentric layers.

In a transverse section of the diaphysis of a long bone, it is noticed that the fundamental substance is excavated by an infinite number of vascular canaliculi, named Haversian canals (Figs. 9, 10). These canals measure from 1-2500th to 1-200th of an inch in diameter, and are parallel to each other and to the larger axis of the bone; they communicate frequently by transverse branches. While the most superficial open on the surface of the bone, beneath the periosteum, and the deepest into the medullary canal, a certain number terminate in the areolæ of the spongy substance at the ends of the bones.

The walls of these canals are constituted by several concentric lamellæ of fundamental substance, in which are lodged the essential elements of the bony tissue. Each canal, with its vessels, its system of concentric lamellæ, its osteoplasts, and its osseous canaliculi, forms a whole (the *Haversian system*) which represents the complete bone in miniature. All the Haversian systems preserve a certain independence; the canaliculi of each, after reaching the periphery, are nearly all reflected towards the centre (the *recurrent canaliculi of Ranvier*) and rejoin the canaliculi of the same system, instead of anastomosing with those of the neighbouring system.

Fig. 10.

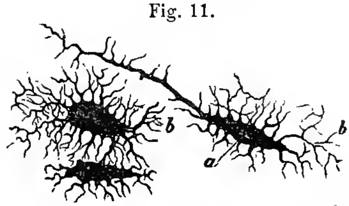


MINUTE STRUCTURE OF BONE, as shown in a thin section cut transversely to the direction of the Haversian canals.

1, A Haversian canal surrounded by its concentric lamellæ; the lacunæ are seen between the lamellæ, but the radiating tubuli are omitted; 2, *ibid.*, with its concentric laminæ, lacunæ, and radiating tubuli; 3, the area of one of the canals; 4, 4, intervening lamellæ, and between them, at the upper part, several very long lacunæ with their tubuli.

Between the Haversian systems, there are the intermediate systems of lamellæ which fill the spaces left through the imperfect contact of the former. In all the long bones there is a *system of peripheral lamellæ*, enveloping, externally, all the Haversian systems; while a *system of perimedullary lamellæ*, more or less perfect, also exists at the inner surface of the medullary canal.

Fig. 11.



LACUNÆ, OR OSTEOPLASTS OF OSSEOUS SUBSTANCE, magnified 500 diameters.
a, Central cavity; *b*, its ramifications.

Sharpey observed that the peripheral bony lamellæ were traversed by fibres (*Sharpey's* or *perforating fibres*), and J. Renaut has remarked in the same lamellæ the presence of elastic fibres.

The proper tissue of bones is a framework of organic matter which has gelatine for its base, and in which are deposited the calcareous phosphates and carbonates which give to this tissue its characteristic hardness. This is easily rendered evident by immersing any bone in dilute nitric or hydrochloric acid; acid dissolve the calcareous salts, but do not act upon the organic framework. So it is, that after some days' maceration the bone becomes flexible, like cartilage, and loses part of its weight, although it preserves its volume and shape. The counterpart of this experiment may be made by submitting it to the action of fire. It is then rendered quite friable, because its organic skeleton has been destroyed, without the earthy salts it contained being affected.

B. *Periosteum.*—This is a very vascular and nervous fibrous membrane which covers the entire bone, with the exception of the articular surfaces and the insertions of tendons and ligaments. Its thickness and adherence are not the same everywhere; it adheres most closely near the ends of bones. By its inner face it corresponds to the surface of the bone, into which it sends prolongations (*arciform fibres*) which ultimately become Sharpey's fibres; by its external face, it is continuous with the surrounding connective tissue and that of the muscular aponeuroses.

The periosteum may be resolved into two layers, though these are not always very distinct. The superficial layer is essentially fibrous, and is formed by a network of elastic fibres containing bundles of longitudinal fibres and cells. The deep layer is a closer elastic network, with finer connective tissue fibres, and a larger quantity of cells and vessels. This is called the *osteogenous layer*, because of its functions.

C. *Medulla*.—The medulla, or marrow, is a pulpy, fatty substance, which fills the medullary canal and the areolæ of the spongy tissue of the bones, and partly the Haversian canals. Somewhat consistent, and of a rosy tint in the bones of young animals, the marrow becomes diffluent and yellow in the bones of those advanced in age, except in the vertebræ of the Horse, Ox, Dog, etc., and in the limbs of the Rabbit. In the first state, it is also mucous or fibrous in the cranial and facial bones undergoing development, and, rosy in colour, it only contains traces of fat; while in the second, it has 96 per cent. of this substance. The medulla of bones is composed of: 1st, some trabeculæ of delicate connective tissue and a network of stellate cells, to support the vessels and nerves; 2nd, fat cells; 3rd, particular cells, named by M. Robin *medullo-cells* and *myeloplaxes*.

The *medullo-cells*, abundant in the red or fœtal marrow, are small cells with a spherical or budding nucleus (*Bizzozero's cells*), analogous to the lymph cells; some are impregnated with hæmoglobine. With regard to the *myeloplaxes*, these are enormous flat cells, irregular in outline, and containing a large number of nuclei. Rare in the yellow marrow, they are more particularly found adhering to the walls of the medullary canal, or the alveoli of the spongy tissue.

D. *Blood-vessels*.—The *arteries* of bones belong to three orders—a distinction based on their volume and the extent of their distribution.

The arteries of the first order penetrate to the interior of the medullary canal of long bones, by a particular orifice—the *nutrient foramen*. They soon divide into two branches, which break up into a network that lines the walls of the canal and enters the tissue of the medulla. This network communicates with the arteries of the second order, which go to the spongy tissue of the extremities of the long bones, penetrating them by the numerous nutritive foramina that surround the epiphyses. Lastly, the arteries of the third order are branches of the periostic network that enters the superficial Haversian canals. These canals may be considered, strictly speaking, as a third category of nutrient conduits. In the flat and short bones there are no arteries of the first order.

Veins accompany the arteries, and are always more voluminous than these; they frequently make their exit by special and very large openings at those points where the spongy tissue is abundant. The veins of bones sometimes exhibit saccular dilatations on their course. Certain veins in the cranial bones have their walls partly or entirely channeled in the bony tissue; they are lined by a simple endothelium.

E. *Lymphatic vessels*.—The existence of these cannot be affirmed.

Nerves.—These belong to the cerebro-spinal and ganglionic system of nerves; the latter are always vaso-motor nerves.

Almost constantly, a somewhat voluminous nerve enters the medullary canal, by passing through the nutrient foramen, and is distributed to the medulla. The compact tissue receives few nerve filaments; while, on the contrary, the spongy tissue at the extremities of the long bones, as well as the short bones, contains many. Certain short bones, such as the vertebræ, are especially remarkable for the numerous nerves they receive.

DEVELOPMENT OF BONES.

The bones, before arriving at the condition in which we see them in the adult animal, pass through several successive phases, the study of which constitutes *Osteogeny.*

Nearly all the bones were originally cartilaginous, those of the roof of the cranium and the face being only represented by fibrous tissue. We will examine the development of these cartilaginous and fibrous bones.

A. *Development of the Cartilaginous Bones.*—In the embryo at an early period, the bones are composed of a *mucous material* analogous to that which enters into the composition of all the other organs; this matter is constituted by a mass of embryonic cells. Later, they become harder, white, and elastic—that is, cartilaginous. Certain portions of the skeleton persist in this condition during the life of the animal. These permanent cartilages are found where the bouy skeleton must have a certain amount of flexibility, and on the articular surfaces.

The temporary cartilages, like the permanent, have a fundamental amorphous or hyaline substance, in which are embedded round cells containing one or several nuclei. But they soon undergo modifications, which result in giving to the pieces they form the hardness and structure of perfect osseous tissue.

These modifications gradually cause the cartilage to disappear, and to be replaced by bony tissue, without the skeleton ceasing for an instant to preserve its form and functions. The process commences by calcification of the perichondrium and of the middle part of the diaphysis, which ensures the stability of the organ. Then the blood-vessels, which are constantly present in temporary cartilages, pass through the diaphysary nucleus, ramify, and are directed in a parallel manner towards the extremities. Simultaneously, the chondroplasts are arranged in parallel series in front of the vessels (*rivulation of the cartilage*), and finish by merging into large, irregular, elongated cavities, incompletely separated by bands of fundamental substance of the calcified cartilage, designated the *directing lines of ossification.*

The blood-vessels enter these cavities, carrying to their surface cells which proliferate, and are differentiated into *osteoblasts* or productive cells of bone. The osteoblasts are deposited, layer upon layer, against the walls of the spaces limited by the lines of ossification, and form, by a kind of secretion, concentric strata of the osseous fundamental system which surrounds them; then the osteoblasts become osteoplasts. The cavities made in the cartilage finish by becoming filled up, except at the centre, where a central cylindrical space remains (Haversian canal), and a blood-vessel.

In the extremities of the bones, where there are no Haversian canals, the preparatory modifications are the same as in the diaphysis, only the cartilaginous cells collect in small irregular masses, and not in parallel piles. Each of these masses forms layers of bone substance, that finish by constituting the lamellæ of spongy tissue at the periphery and medullary tissue at the centre, to fill the areolæ of the latter.

In this way is accomplished the transformation of cartilage into bone. As will have been observed, it is not a mere calcification of the cartilaginous tissue, but a real substitution of bone tissue, presenting the following phases: 1. Perichondrial and endochondral calcification in places (nuclei or centres of ossification). 2. Invasion of the centres of ossification by vessels, rivulation of the cartilage. 3. Medullization of the cartilage, and formation of osteoblasts. 4. Development of the bone tissue, appearance of the osteoplasts.

Fig. 12.

CARTILAGE AT THE SEAT OF OSSIFICATION, showing at its lower portions the clusters of cells arranged in columns, each of which is enclosed in a sheath of calcified intercellular substance.

B. *Development of the Fibrous Bones.*—The bones originally fibrous are not merely charged with lime salts in order to acquire a bony appearance. They do not pass through a transitory cartilaginous state, but the phenomena of ossification take place in the fibrous tissue in the following manner:—

The fasciculi of connective tissue become calcified, separate here and there from one another to form spaces, into which blood-vessels enter or osteoblasts appear. To this phase of medullization succeeds the phase of ossification, which is accomplished in the same manner as in the cartilaginous bones. Only the directing lines are represented by connective fasciculi, which later become Sharpey's fibres.

C. *Progress of Ossification.*—Ossification commences simultaneously in several parts of the skeleton, and in each of the bones in particular—though not throughout their entire extent at the same time. On the contrary, in certain determinate points of the cartilaginous or fibrous mass, osseous tissue is developed which, gradually extending, ends by completely invading it. These points are named *nuclei* (or *centres*) of ossification. The nuclei are *primitive* or *complementary*. The latter, termed *epiphyses*, are in a fashion added to the bone, and wholly or partly form certain apophyses.

Although these centres of ossification increase from day to day, they nevertheless remain for a long time independent of each other, and are united only by cartilage. When the skeleton is completely developed, the various centres of ossification become joined to each other, and the entire bone forms one piece; there are no longer any apophyses.

Up to the present time, attempts to discover the laws which govern the appearance of the centres of ossification have been futile; the size of the bone counts for nothing; and the influence of proximity to the centres of circulation, which has been sometimes brought forward (for the sternum, for example, which is never completely ossified), cannot be accepted. The law which presides over the union of the centres of ossification has also been sought for. A. Bérard imagined he could formulate it in the following proposition: *Of the two extremities of a long bone, it is always that towards which the nutrient foramen is directed that is first united to the body of the bone.* But to Bérard's law there are numerous exceptions; and in order to demonstrate that it is not absolute, it is sufficient to indicate that the direction of the nutrient foramen varies much, not only in similar bones of different species of animals, but also in similar bones of the same species; and yet the progress of ossification is always the same.

The period when fusion of the epiphyses terminates in the domestic animals is still little known; fusion is evidently complete when growth is achieved, but this period is markedly modified by hygiene and the food animals receive. Renault and some breeders have observed, that in the precocious breeds of cattle the evolution of the teeth is more rapid than in the common breeds. More recently, Sanson has affirmed that precocity, characterized by this prompt dental evolution, is marked by a more rapid fusion of the epiphyses, and he believes there is a direct relation between the evolution of the teeth and that of the bones. According to this principle, in the Horse the fusion of the epiphyses should commence and terminate between three and five years of age.

Toussaint, however, did not share this opinion. In the Ox, Sheep, and Horse, he remarked that the first centres of ossification appeared in the body of the flat and the long bones, and in the centrum and arches of the vertebræ. When the first half of gestation had not been passed, no other points of ossification were seen. It is necessary to add, however, those of the second and third phalanges and the calcis, which comport themselves as long bones.

In the last half of gestation, ossification invades the complementary nuclei, as well as the short bones; the exceptions are the pisiform bone and the inner condyle of the humerus in the Calf and Foal, and the large and small sesamoid bones in the Calf only. Ossification of these bones of the skeleton is slow. It must also be mentioned that at birth the complementary nuclei of the coxæ are not yet visible, and they are not seen until ten months or a year afterwards.

With regard to fusion of the epiphyses, it occurs at the following periods in the principal bones of the *Horse;* at the twelfth to the fifteenth month in the second phalanx at first, then in the first phalanx; at the fifteenth to the eighteenth month in the middle metacarpal, afterwards in the metatarsal. At this age fusion also occurs at the upper end of the radius and inferior extremity of the humerus; from twenty months to two years, at the lower end of the tibia; from three to three and a half years, at the upper extremity of the humerus, at the two ends of the femur, and at the upper end of the tibia; lastly, about five years, in the bodies of the vertebræ and in the coxæ.

In the *Ox*, ossification progresses at about the same rate as in the Horse, except that there is a little greater precocity in the fusion of the epiphyses of the humerus and radius, which are fused at the same time as those of the phalanges, and matacarpal and metatarsal bones. In this animal, the two lateral halves of the latter bones are united before union of the inferior epiphysis to the body of the bone. The *Sheep* offers an interesting peculiarity, in that the humero-radial epiphyses are consolidated before those of the phalanges, and towards the tenth month.

If the results of these observations, made on our principal domestic animals, are compared with the evolution of the dental system, we are compelled to conclude, with Toussaint, that fusion of the epiphyses does not commence at the same time as the eruption of the first permanent teeth. If a relationship exists between the evolution of the teeth and that of the bones, it has yet to be demonstrated in an exact manner.

Toussaint has also studied the course of ossification in the Dog, Pig, and Rabbit. In the *Dog* at birth, none of the complementary nuclei have been invaded by ossification. Consequently, bone tissue is only found in the diaphysis of the long and flat bones. In the three months after birth, the great majority of the epiphyses commence to ossify; and after this period there only remain the pyramidal bone and the complementary nuclei of the coxæ, in the cartilaginous condition; the ossification of these latter commence at from five to six months.

The skeleton of the *Rabbit* is, at birth, in a condition almost identical with that of the Dog; nearly all the epiphysary nuclei of the humerus and that of the lower end of the femur, however, show osseous points.

In the *Pig*, at birth ossification is much more advanced than in the Dog; but it is less so than in the larger Herbivora.

The fusion of the epiphyses has been studied in the *Dog*. It commences at five months, in the phalanges and metacarpals, and continues in the humerus and radius, the corresponding epiphyses of which are consolidated at nine months; at eighteen months there can be distinguished the nuclei at the upper border of the scapula, the upper end of the humerus, inferior extremity of the radius and ulna, the epiphyses of the femur, and the bodies of the vertebræ. The latter facts support the preceding ones, and likewise demonstrate that the conclusions of Sanson are probably too absolute.

Growth of the Bones.

Bones increase by the superposition of new elements, while the soft parts of the organism grow by the interposition of new elements in the mass of pre-existing elements. The manner in which this apposition of new elements is accomplished is not the same in the long, the flat, or the short bones.

1. *Long Bones.* As a general rule, the long bones elongate by the growth and ossification of the temporary cartilage situated between the diaphysis and the osseous nuclei at the extremities. Consequently, elongation ceases when the primitive or complementary nuclei are fused with one another. The increase in length in the bones of the limbs does not take place everywhere in the same proportion. Duhamel, Flourens, and particularly Ollier and Humphry, have remarked that, in the thoracic limb, the extremity furthest removed from the humero-radial articulation grows fastest; while in the abdominal limb, the extremity most distant from the femoro-tibial articulation grows the least.

With regard to the increase in thickness of the bone, this occurs by ossification of the deeper layer of the periosteum—the *osteogenous layer*. The experiments of the authors just mentioned irrefutably demonstrate this, and those of Ollier have even proved that the periosteum may produce bone at a point where it has been transplanted.

The periostic bone is developed according to the process of ossification in the fibrous tissue. In a transverse section of the diaphysis of a growing long bone, there is seen, as Laulainé has indicated, concentric circumferences united by radii of osseous substance. The diaphysary portion of the periostic bone is fused with the extremities, through the medium of the *ossification notch* of Ranvier—a prolongation of the periosteum into the articular enlargement around the cartilage of conjugation. The formation of bone tissue in the deeper layer of the periosteum is very active during the youth of animals, but it soon diminishes, and ceases completely in advanced age.

If the phenomena of growth were not counterbalanced by those of absorption, long bones would acquire an enormous thickness and weight. But in the first period of life, in proportion as new layers are applied to the surface of bones, the deeper parts—those occupying the axis of the diaphysis—disappear by absorption. In this way the medullary canal is formed, and a just proportion established between the volume and weight of the skeleton.

When the bones are completely formed, during the entire adult period the process of destruction is equal to that of growth, so that their weight and composition does not vary. At a later period, absorption is greater than the formative force, which in old age is altogether in abeyance; so that the organic matter of the bones is rarefied, and these lose their elasticity and gain in fragility.

It has been remarked that the development of the bones is subordinate, in a certain measure, to the activity and resistance of the organs in their vicinity. Lesshoft and Popoff believe that the development of a bone is in proportion to the activity of the neighbouring muscles, that the pressure of external organs—such as an aponeurosis—may produce torsion in a bone and retard its growth, so that its greatest thickness will correspond to the point where the surrounding resistances are at a minimum. Ollier, however, has noted that the long bones become more elongated when they do not sustain pressure on their extremities.

2. *Flat Bones.*—These bones have sometimes only one primary nucleus of ossification, placed in the centre. They grow by the increase of this nucleus, which gradually invades the mass of the bone in radiating from the centre towards the periphery. When they have several nuclei, some of these are at the margin, and in such a case the bones increase by ossification of the *marginal epiphyses* and growth of the central nucleus.

Flat bones increase in thickness by the formation of sub-periosteal layers, and by the development of the spongy tissue between the two compact plates.

3. *Short Bones.*—These grow in thickness by the progressive ossification of the osteogenic layer of the periosteum; and in length by ossification of the epiphysary cartilages, when they possess complementary nuclei.

Nutrition of Bones.

The experiments which consisted in feeding young animals with madder, and afterwards examining their osseous system, have for a long period demonstrated the nutrition of bones. When bones cease to grow, nutrition becomes less active; but it is evident that it does go on, in order to maintain the organic matter of the osseous tissue in a proper condition.

The abundance of vessels carrying blood to all parts of the bone tissue, alone suffices to prove the existence of a nutritive movement in these apparently stony organs.

CHAPTER II.

THE BONES OF MAMMALIA IN PARTICULAR.

Article I.—Vertebral Column.

The vertebral column, or spine, is a solid and flexible stalk situated in the middle and upper part of the trunk, of which it forms the essential portion. It protects the spinal cord and sustains the thorax, as well as the principal organs of circulation, respiration, and digestion. Articulated anteriorly with the head, and terminating in a point at its posterior extremity, this stalk is formed by a somewhat considerable assemblage of short, single, tuberous bones, to which has been given the name of *vertebræ*. These bones, though all constructed on a uniform type, yet do not offer the same configuration throughout the whole spine. The differences they present in this respect have permitted their being divided into five principal groups; whence the division of the vertebral column in five regions, which are, enumerating them from before to behind: 1. *Cervical region*. 2. *Dorsal region*. 3. *Lumbar region*. 4. *Sacral region*. 5. *Coccygeal region*. The first comprises seven vertebræ, which serve as a base for the animal's neck; the second has eighteen, against which the ribs are placed; the third has only six, which correspond to the loins; in the fourth there are five, constantly fused into one mass in the adult, to constitute a single bone—the *sacrum*; while the fifth possesses a variable number of small degenerate vertebræ, gradually decreasing in size to form the tail. The pieces constituting the first three regions are called *true vertebræ*; those of the last two are designated *false vertebræ*.

The subjoined table indicates the number of vertebræ in each of the regions of the spine, in the horse and other domestic Mammalia.

Animals.	Vertebræ.				
	Cervical.	Dorsal.	Lumbar.	Sacral.	Coccygeal.
Horse	7	18	6 or 5	5	15—18
Ox	7	13	6	5	16—20
Sheep	7	13	6—7	4	16—24
Goat	7	13	6	4	11—12
Camel	7	12	7	4	15—18
Pig	7	14	6—7	4	21—23
Dog	7	13	7	3	16—21
Cat	7	13	7	3	21
Rabbit	7	12	7	4	16—18

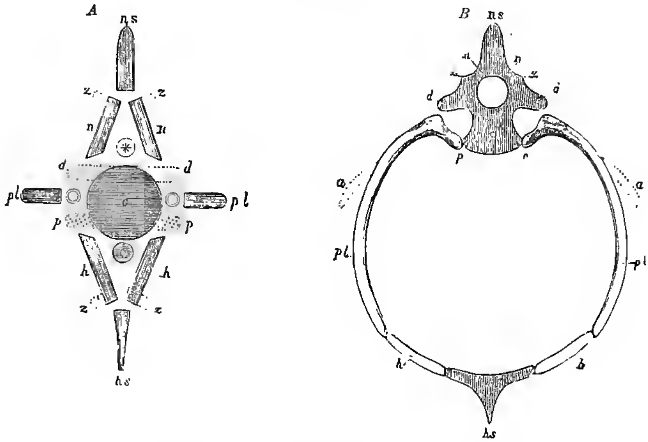
The characters belonging to all these vertebræ will be first studied; then a particular description of those of each region will be given; and, finally, an examination will be made of the spine as a whole.

Characters common to all the Vertebræ.

Each of these small bones is pierced from before to behind by a wide opening—the *spinal foramen*, or *vertebral canal*; whence results, for the entire spine, a long canal traversing its whole length, and which lodges a very important portion of the nervous centres—the spinal cord. This canal, which traverses the vertebræ from one end to the other, transforms it into a ring in which we recognize, for facility of description, two parts—the one inferior, the other superior. The first, or *body*, is very thick, and forms the base of the vertebræ; the second, which is thin, has been designated *spinous* or *spinal*—from one of the peculiarities it presents, or *annular*—because it circumscribes the major portion of the spinal foramen. This division is not altogether an arbitrary one, for the body and the annular portion constitute, in the fœtus, two distinct pieces, which do not become united for a long time after birth.

BODY (*centrum*).—The shape of the body of a vertebra is that of a prism

Fig. 13.



ELEMENTS OF A VERTEBRA. (AFTER OWEN.)

A, Ideal typical vertebra; B, Actual thoracic vertebra of a bird; *c*, Centrum (or *body*), giving off, *d*, *d*, the diapophyses, and *p*, *p*, the parapophyses (*transverse* and *articular processes*); the neural arch, enclosing the spinal cord, is formed by *n*, *n*, the neurapophyses (*laminæ*), and *n*, *s*, the neural spine (*spinous process*); the hæmal arch, enclosing the great centres of the circulation, is formed by *h*, *h*, the hæmapophyses (*costal cartilages*); and *h*, *s*, the hæmal spine (*sternum*). From both the neurapophyses and hæmapophyses may be given off the zygapophyses, *z*, *z*. The lateral arches, which may enclose the vertebral arteries, *o*, *o*, are completed by the pleurapophyses (*ribs*), *pl.*; these in B are bent downwards, so as to form part of the hæmal arch, and give off the diverging appendages, *a*, *a*.

with four faces, of which two only—the *superior* and *inferior*—are free, and can be studied in the adult; the two lateral faces are united and confounded with the annular portion. This prism also presents two *extremities*—an *anterior* and *posterior*.

Faces.—The *superior face*, limited in extent, forms part of the spinal foramen, constituting its floor. It exhibits: 1. On the middle line, two roughened, prominent surfaces, representing two triangles, whose summits are opposed. 2. On the sides, two depressed smooth surfaces, perforated by one or more openings that lead to the interior of the bone. The *inferior face* is divided into two lateral portions by a median crest (the hæmal spine).

Extremities.—The *anterior* has a prominent convex head, more or less detached. The *posterior* offers a cavity for the reception of the head of the next vertebra. These two planes—the one convex, the other concave—do not come into immediate contact; an elastic, flexible fibro-cartilage, firmly attached to each, is interposed between them.

Annular Portion (*neural arch* or *neuropophyses*).—This is formed by an osseous plate that curves suddenly downwards, in the shape of an arch, the two extremities of which approach each other, enclose the body, and become united to it. It offers for study: 1. An *internal* and an *external* surface. 2. An *anterior* and a *posterior* border.

Surfaces.—The *internal* surface, concave and smooth, forms, with the superior face of the body, the spinal foramen. The *external*, convex and irregular, presents: 1. A single prominence, raised in the middle of the superior portion, and named the *spinous process* (*neural spine*). 2. The *transverse processes* (*diapophyses*) are a double pair of eminences, one on each side, and projected transversely outwards.

Borders.—The *anterior border* has two articular facets looking upwards: these are the *anterior articular processes* (*prezygopophyses*), right and left. In each is a notch which, when placed in opposition to a similar excavation in the preceding vertebra, forms the *intervertebral foramen.* The *posterior border* presents the same peculiarities, with this difference, that the articular faces of the *posterior articular processes* (*postzygopophyses*) are inclined downwards, to correspond with the anterior facets of the succeeding vertebra.[1]

Structure of the vertebræ.—The compact substance, which is abundant in the spinous portion, forms in the body an extremely thin layer, inclosing a voluminous nucleus of spongy tissue. The latter is traversed by numerous venous canals, which open on the surface of the bone.

Development.—It has been already shown that the body and spinous portion of a vertebra constitute, in young animals, two distinct pieces. Each was primarily formed from two lateral centres, which met on the median line. In the body, the fusion of these centres is so prompt, that it is generally believed, perhaps justly, that the development of this part of the vertebra proceeds from a single centre of ossification. The union of the two centres in the annular portion, usually designated the *vertebral laminæ* (*parapophyses*), is slower. It commences in the most anterior vertebræ, and is latest in the sacral and coccygeal regions. To the three principal pieces of the vertebra in process of ossification, are added, at a subsequent period, complementary centres of ossification, variable in number according to the regions and species of animal; there is always one for each of the anterior and posterior surfaces of the vertebral bodies; while others, much less constant, concur to form the spinous and transverse processes.

Characters proper to the Vertebræ of each Region.

A casual inspection of a vertebra might suffice, strictly speaking, to distinguish the region of the spine to which it belonged. For instance, a cervical vertebra is recognized by its volume, the absence of a spinous process, and the foramen which traverses the base of its transverse processes. The dorsal vertebra is conspicuous by its tubercular transverse processes, and by being furnished, outwardly, with an articular surface, as well as by the depressions on its body destined to receive the heads of the ribs. The lumbar vertebra has its long flattened transverse processes; while the coccygeal vertebra offers rudi-

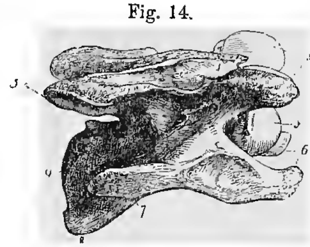
([1] Vertebræ which have centra concave at both ends, are designated *amphicælous.* Those distinguished by a concavity in front and a convexity behind, are known as *procælous;* but if the cavity is behind and the convexity before, they are then named *opisthocælous.* **A vertebra** of the above description belongs therefore, to the *opisthocælous* class.)

mentary laminæ and processes. There is no necessity for noticing the sacrum, the five pieces of which form one bone—a feature that markedly distinguishes it from the other regions of the vertebral column. But these few distinctive characteristics do not satisfy the requirements of descriptive anatomy; so that it is necessary to undertake a more extensive study of each of these regions.

1. Cervical Vertebræ.

General Characters.—These vertebræ, the longest and thickest in the spine, present generally a cubical form. They are usually distinguished from the vertebræ of the other regions by the following characters: The *inferior spine* of the body is strongly marked, especially behind, where it terminates in a small tubercle. The *head* is well detached from the remainder of the bone, and describes a very short curve. The *posterior cavity*, wide and deep, represents a veritable cotyloid depression, which is too large to fit the head exactly; the intermediate fibro-cartilage on these two surfaces is also of a great thickness. The *spinous process* forms a simple roughened, and but slightly prominent, ridge. The *transverse processes*, very developed, are elongated in an antero-posterior direction, and inclined downwards. In this region they are designated the *trachelian processes*, because of their relations with the trachea; a foramen that traverses them from before to behind at their base has been, for the same reason, named the *trachelian foramen* (*vertebral foramen*). The *articular processes*, large and prominent, are inclined downwards and inwards. The *notches* are wide and deep.

Fig. 14.



A CERVICAL VERTEBRA.

1, Superior spinous process; 2, anterior articular processes; 3, posterior articular processes; 5, anterior convex face of body; 6, 7, transverse processes, with their tubercles or rudimentary ribs; 8, inferior crest, or spine; 9, concave posterior face.

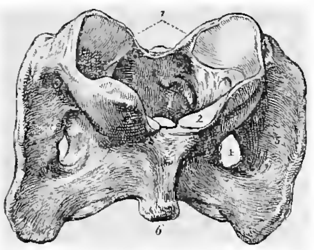
Specific Characters.—The seven cervical vertebræ are reckoned from before to behind, and receive numerical names indicating their place in the region.

First.—The first vertebra of the neck, which has been named the *atlas*,[1] deserves a very careful description. At first sight there is recognized the great development of its transversal diameter, the considerable dimensions of the spinal foramen, and the thinness of its body. The intra-spinal face of the latter is divided into two portions by a transverse ridge: one anterior, furnished with ligamentous imprints, exhibits, laterally, two deep excavations, which lodge the venous sinuses; the other, posterior, is smooth and concave from side to side, and forms an articular surface into which is received the odontoid process of the axis; this surface takes the place of the cotyloid cavity. The inferior spine of the body appears as a large tubercle (Fig. 15, 6). The head is absent, and is replaced by two concave facets. The anterior articular processes have their gliding surfaces looking downwards; they are joined to the two preceding facets to constitute two large diarthrodial cavities, which articulate with the occipital condyles (Fig. 15, 1). There is no spinous process, but a roughened surface instead. The transverse processes are large, flattened above and below, inclining forwards and downwards, and are provided with a thick rugged lip. Posteriorly,

[1] Rudimentary ribs are sometimes attached by ligaments to the ends of the transverse processes (*Lesbre*).

quite at their base, and on each side of the spinal foramen, they show two large vertical facets which represent the posterior articular processes ; these facets are uneven, are confounded with the articular cavity of the upper face of the body, and correspond to the two analogous facets of the axis. Each transverse process is pierced at its base by two foramina, which traverse it from below upwards. The posterior represents the vertebral foramen of the other vertebræ ; while the anterior is continued to the external surface of the process by a wide, deep, but very short channel, running from without to within, and joins a third foramen, which enters the spinal canal. These last two openings, with the demi-canal which unites them, replace the anterior notch ; the posterior is altogether absent. Lastly, an inflected venous canal, the position of which varies, and it is also sometimes absent, crosses the laminæ of the atlas, and opens, on one side, into the spinal canal, and on the other, beneath the transverse process. The *atlas* contains much compact tissue, and is generally developed from six centres of ossification : two for the body, which at an early period becomes a solid piece, and two for the annular part ; the other two are complementary centres, each of which forms one of the two posterior undulated facets and lip of the corresponding transverse process.

Fig. 15.

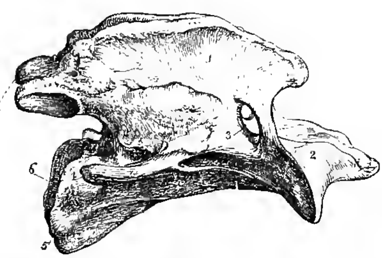


ATLAS ; INFERIOR SURFACE.

1, Articular cavities for condyles of the occipital bone ; 2, articular facet ; 3, vertebral or antero-internal foramen ; 4, posterior, or cervical foramen ; 5, transverse process or wing ; 6, tubercle representing the inferior spinous process ; 7, superior arch, forming the roof of the spinal foramen.

Second.—This is named the *axis*, or *dentata* (Fig. 16). It is the longest of all the cervical vertebræ ; those which succeed it gradually diminish in length and in thickness. The body of the axis has no increase anteriorly, but a conical process termed the *odontoid*, which is flattened above and below, concave and rough from one side to the other on its superior face ; convex in the same direction and perfectly smooth on its inferior face. The latter represents an articular half-hinge, around which glides the concave articular surface on the superior face of the body of the atlas. The anterior articular processes are carried to the base and to each side of the odontoidian pivot, in the shape of two undulated facets, which are confounded with the gliding surface of the latter, the destination of which has been already noted. The spinous process, very large and elongated antero-posteriorly, is divided behind into two roughened lips. The transverse processes are slightly developed, and terminate posteriorly in a single tubercle, directed backwards. The anterior notches are very deep, and are most frequently converted into foramina. This *vertebra*, although voluminous, is light, in consequence of its containing much spongy substance. In the young animal, the odontoid process and the articular surfaces on each side, constitute

Fig. 16.



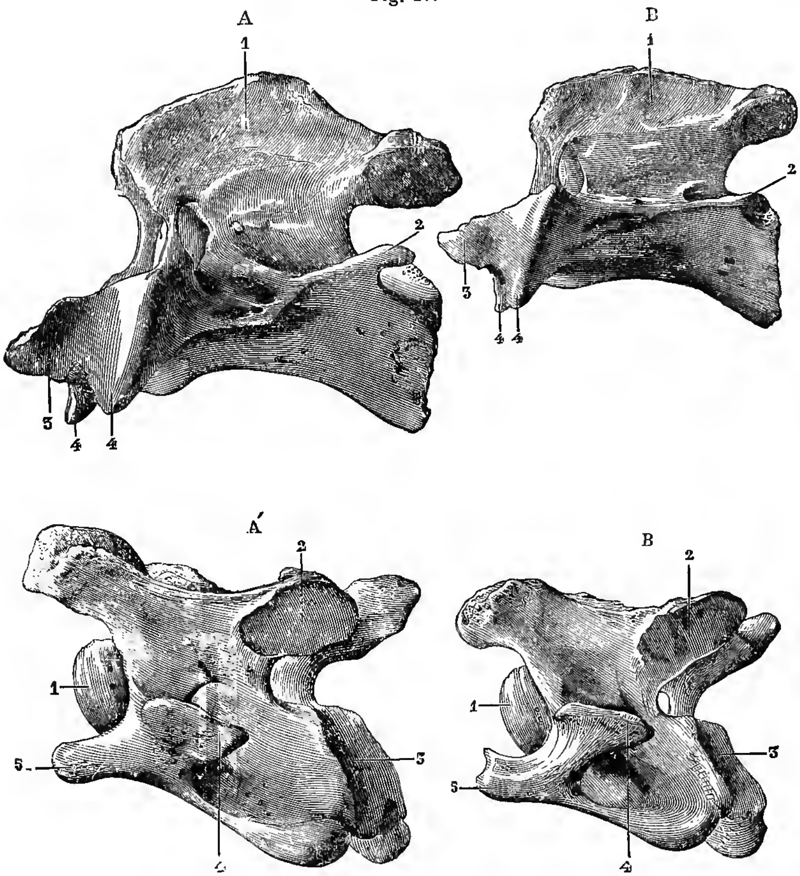
THE AXIS, OR DENTATA ; LATERAL VIEW.

1, Superior spinous process ; 2, odontoid process ; 3, intervertebral foramen, or hole of conjugation ; 4, body ; 5, inferior spinous process ; 6, 7, inferior and superior articulating processes.

two centres, distinct from each other and from the body of the vertebra. After the axis, the cervical vertebræ diminish in length and increase in thickness; while the obliquity of their articular processes becomes more pronounced the more distant they are from that vertebra.

Third, fourth, and fifth.—Each of these has, at its transverse processes, two prolongations—one anterior, the other posterior. The inferior face of their bodies

Fig. 17.



AXIS AND SIXTH CERVICAL OF THE HORSE AND ASS.

A. *Axis of the Horse.* 1, spinous process; 2, transverse process; 3, odontoid process; 4, lateral articular facet.
B, *Axis of the Ass.* Same numbers and same signification.
A′, *Sixth cervical vertebra of the Horse.* 1, Articular head; 2, posterior articular process; 3, articular cavity; 4, posterior prolongation of the transverse process; 5, anterior ditto.
B′, *Sixth cervical vertebra of the Ass.* Same numbers and same signification.

exhibits a median spine terminated posteriorly by a tubercle, which gradually increases in volume from the third to the fifth vertebra.

The *third* presents, between its anterior and posterior articular processes, an almost complete gap; if its anterior extremity be placed on a horizontal plane, it will touch that plane by its articular and transverse processes and its head.

In the *fourth*, the articular processes are united by a thin, sharp osseous plate, notched only in front. Laid on a horizontal plane, the head remains some distance from that plane. The *fifth* is recognized by the continuous, thick, and rugged lamina which unites the articular processes, and by the tubercle of the inferior spine on the body, which is in shape like the heart on a playing-card.

Sixth.—This is distinguished by the slight prominence of the spinous process, but particularly by the almost total disappearance of the inferior spine, and the presence of a third prolongation, very strong and inclining downwards at its transverse process—a circumstance to which this vertebra owes its designation of *tricuspid.*

Seventh.—This has received the name of *prominens*, because its spinous process, terminating in a point, is more distinct than in the preceding vertebræ, the axis excepted. It exhibits, besides . deep imprints, which replace the inferior spine ; a concave demi-facet on each side of the posterior cavity of the articulation of the head of the first rib ; a particular disposition of its transverse processes, which are unituberculous ; the complete absence of the vertebral foramen ; and, lastly, the depth and width of its notches. The spinal foramen, which has already assumed a somewhat considerable diameter in the sixth cervical vertebra, is still larger in the seventh.

Ass.—The cervical vertebræ in this animal much resemble those in the Horse. Studying them more closely, however, it is possible to discover certain differences which distinguish them from those of the other Equidæ. Thus, the rugosities on the arch of the *atlas* are much less marked than in the Horse, and form a kind of thick depressed tubercle. The vertebral foramen is very large in proportion to the size of the vertebra, and the canal uniting the two portions of the anterior foramen of the transverse process is deep and protected by a well-defined rim. The *axis* has a less elevated spinous process than that of the Horse ; its upper border, nearly parallel with the transverse process, is more deeply divided into two lips, and the summit of its transverse process extends backwards to the articular process, while in the Horse it does not go beyond the origin of the latter. In the *third*, the lamina uniting the two prolongations or points of the transverse processes, is notched behind the anterior prolongation, instead of being notchless as in the Horse. In the *fourth* and *fifth* this notch is still more marked. In every instance the anterior prolongation of the transverse process is always more detached and better circumscribed in the Ass than in the Horse. The same remark applies to the *tricuspid ;* the posterior prolongation is also better detached, and the middle prolongation extends nearly to the articular cavity of the vertebra—a prolongation which, in the Horse, does not exceed one-half the length of the posterior one. The *seventh* differs little from that of the Horse ; nevertheless, the uni-tubercular transverse process has, in front, a small sharp projection which resembles somewhat the anterior prolongation of the bicuspid processes.

In the **Mule** and **Hinny**, the cervical vertebræ hold the middle place between those of the Ass and the Horse.

Differential Characters of the Cervical Vertebræ in the other Domesticated Animals.

A. **Ox, Sheep, and Goat.**—The cervical vertebræ of these animals differ from those of Solipeds by their shortness, and the greater development of their insertion eminences. In the *Sheep* and *Goat* they are relatively longer than in the *Ox*. The transverse processes of the *atlas* are less inclined than in the Horse, and have no vertebral foramina; the posterior facets for articulation with the axis, are nearly flat and join each other. The *axis* has a semi-cylindrical, not a conical, odontoid process, which is so concave on its upper surface that it looks like a groove. Its spinous process is not so thick as in the Horse, and is not bifid posteriorly.

In the *five succeeding vertebræ*, a rugged continuous lamina unites the anterior articular processes to the posterior. The spinous process inclines forward, and is flattened transversely at its summit, which is sometimes bifid; it progressively increases in height from the third to the fifth vertebra.

In the *sixth*, the transverse processes have only two prolongations—a superior and inferior; the latter, large and flattened on both sides, is bent abruptly downwards. The spinous process has already attained the height of 1½ to 2 inches in this vertebra, and is flattened laterally.

The *seventh* well deserves the name of *prominens*, its spinous process being no less than from 4 to 4⅗ inches (see Figs. 6 and 7).

B. **Camel.**—In the *Camel*, the cervical vertebræ are longer and thinner than in the other large domestic animals. Altogether, they form one-third of the total length of the spine. Their vertebral laminæ are deeply notched before and behind, which allows them to easily enter the spinal canal. Their articular processes are convex, and from the second to the sixth inclusively, the vertebral foramen is small and deeply placed in the laminæ.

The *atlas* is distinguished from that of the Horse and Ox by the absence of the tubercle on the inferior face of the body, and the shortness of the transverse processes, of which the border is thin and sharp. The vertebral foramen makes a somewhat long course in the transverse process of this vertebra, and opens at the bottom of the excavation in which the anterior intervertebral foramina meet—the latter being double.

The *axis* is very long and constricted in its middle; the inferior crest is only slightly salient; there are double invertebral foramina, the largest of which is divided by a bony septum; the odontoid process is as in the Ox. The other cervical vertebræ gradually diminish in size and increase in thickness from before to behind.

In the *third*, *fourth*, and *fifth*, the transverse processes are bi-tuberculated.

In the *sixth*, the transverse process is a wide and thick plate, inclining downwards.

The *seventh* is recognized by its long spinous process and the smallness of its transverse process, which has a larger and more obvious vertebral foramen than the other vertebræ (see Fig. 8).

C. **Pig.**—Of all the domesticated animals, this has the shortest, the widest, the most tuberous, and consequently the strongest cervical vertebræ. The body of these bones has no crest on the inferior face; the head, but little detached, is scarcely round, and looks as if driven back on itself; consequently, the posterior cavity is not deep. The vertebral laminæ are very narrow, and scarcely extend from one part of the vertebra to the other in the superior portion, so that the spinal canal appears at this point to be incomplete.

In the *atlas*, the transverse processes are less inclined than in Ruminants; the vertebral foramen is not constant, and when it exists, opens on one side, under the transverse process, and on the other, on its posterior margin, after pursuing a certain track in the substance of the bone.

The odontoid process of the *axis* is constricted at its base. This vertebra is distinguished by its high and thin spinous process inclining slightly back, by its transverse processes being but slightly prominent, and perforated by an enormous vertebral foramen.

In the *four succeeding vertebræ*, the spinous process terminates in a blunt point, and inclines forward; slightly salient in the first, it gradually rises in the others. The transverse processes form two prolongations: one, the superior, is tuberous, and is joined to the anterior articular process by a plate of bone, which is pierced by a foramen; the other, the inferior, flattened on both sides, bent downwards, and large, as it belongs to a posterior vertebra, transforms the inferior face of these vertebral bodies into a large groove. The *seventh* has a spinous process as long as those of the dorsal region. A perforated bony plate, as in the preceding vertebræ, unites the anterior articular process to the single tubercle composing the transverse process; the latter is continued back nearly to the posterior notch by a second plate, also perforated with a foramen (see Fig. 3).

D. **Dog** and **Cat.**—In these animals, the cervical vertebræ are long and thick, and much resemble those of Solipeds. Nevertheless, besides their smaller volume, they are distinguished: 1. By the disposition of their corresponding articular surfaces; the anterior, or head, is nearly flat, and is even slightly excavated in its centre; the posterior, or cavity, is but little hollowed to receive the head of the next vertebra; 2. By the width of the vertebral laminæ, which overlap one another; 3. By the height of their spinous processes, which increases as the vertebræ extend back: 4. By the great extent of the anterior and posterior articular processes, which are united by means of a continuous and very salient bony plate, that considerably augments the transversal diameter of each vertebra.

In the *atlas*, the articular surface for the odontoid pivot is confounded in front with the cavities which correspond to the occipital condyles. The two facets which are annexed posteriorly to this articular surface, instead of being plane or gently undulated, as in the other domesticated animals, are transformed into real glenoid cavities. The transverse processes are carried directly outwards and a little backward; the lip which borders each is slightly raised; of the two foramina which replace the anterior notch, one only exists, and this penetrates to the interior of the spinal canal; the other is merely a simple notch.

In the *axis*, the odontoid process is cylindrical, narrow at its base, and bent a little upwards; the lateral facets of this eminence represents true condyles. The spinous process is very thin and undivided, and is curved forward above the laminæ of the atlas. The anterior notches are never converted into foramina.

The *third* cervical vertebra is the largest: and the *succeeding* ones gradually diminish in thickness to the last, contrary to what occurs in the other species. The *seventh* does not show the spinous process so developed as in Ruminants and Pachyderms (see Figs. 3, 4, 7).

E. **Rabbit.**—The cervical vertebræ in this animal somewhat resemble those in the Cat, though they differ in certain general and particular characters. Thus, in the Rabbit they become larger as they proceed backward; the *atlas* has its transverse processes horizontal, and they are narrow at their origin; the *axis* has a bifid tubercle at the posterior extremity of its spinous process, and a notch below it; the *succeeding* vertebræ are thin; the *fourth*, *fifth*, and *sixth* are trifid in their transverse processes; and the *seventh* has a short spinous process.

2. Dorsal Vertebræ (Fig. 18).

General Characters.—In the dorsal vertebræ the *body* is very short, and in front has a large slightly projecting head; behind, it has a shallow *cavity*. Laterally, these vertebræ present, at the base of the transverse processes, four concave *articular facets*, the two anterior of which are situated near the head, while the posterior two are hollowed out of the border of the articular cavity of the body. Each of these facets is joined to an analogous facet on the neighbouring vertebra to form a small excavation, into which is received the head (or *capitulum*) of the corresponding rib. The *spinous process* is very high, is compressed on both sides, inclines backwards, and its summit is terminated by a tubercle. The *transverse processes* are unitubercular, and directed obliquely outwards and upwards; on their external aspect they have a diarthrodial plane facet which corresponds to the tuberosity (or *tuberculum*) of the rib (and may therefore be named the *tubercular transverse process*). The *articular processes* are narrow, and constitute simple unrelieved facets cut on the base of the spinous process. The *posterior notches* are deep, and sometimes converted into foramina.

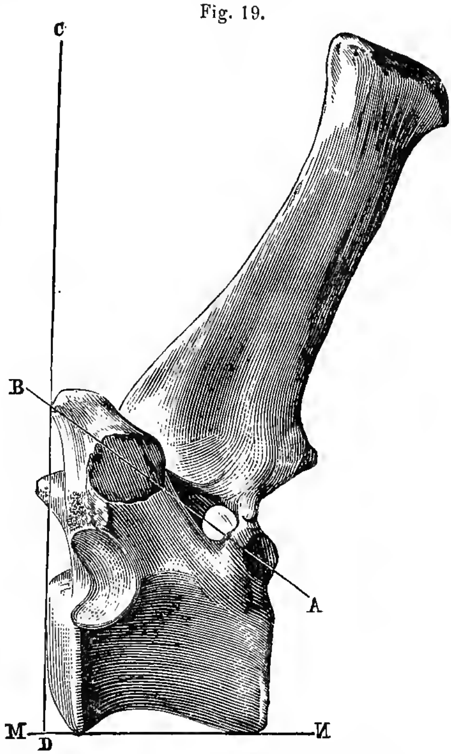
Fig. 18.

TYPE OF A DORSAL VERTEBRA (THE FOURTH).

1, Body, 2, 2, articular facets for the head of the rib; 3, articular facet for tuberosity of the rib; 4, articular processes; 5, spinal foramen; 6, tuberous base of spinous process; 7, posterior articular face of body; 8, 8, transverse processes; 9, superior spinous process; 10, anterior articulation of body.

Specific Characters.—None of the eighteen dorsal vertebræ differ much from the type just described; and it is difficult to establish special characters for each. It is, nevertheless, possible to assign to a dorsal vertebra, approximately, the rank it should occupy, in accepting the following facts as a guide: 1. The vertical diameter of the *vertebral bodies* augments progressively from before to behind. Their lateral diameter, which determines that of the spinal canal, becomes, on the contrary, less from the first to the tenth vertebra; after which it assumes increasing proportions to the last one. The articular surfaces, which serve for the mutual contact of head and cavity, become larger and shallower in proportion as the vertebræ are more posterior. The inferior spine on the body is very salient and tuberculated in the two first vertebræ, very acute in the third and fourth; it disappears in the sixth and ninth, to reappear and become more marked from the tenth to the last. 2. The *intervertebral cavities*, intended for the reception of the heads of the ribs, diminish in depth and extent from the first to the last. 3. The longest *spinous process* belongs to the third, fourth, and fifth vertebræ; those which follow gradually decrease to the eighteenth. Their width diminishes from the second to the eighth; it afterwards increases in a progressive manner in the succeeding vertebræ; from the second to the tenth vertebra, the summit of the spinous process is large and tuberculated; in the last seven it is flattened laterally. Their obliquity is less marked as they proceed backwards; in the sixteenth and seventeenth vertebræ, the spinous process is nearly vertical; it inclines slightly forward in the eighteenth. Those of the tenth, eleventh, and twelfth vertebræ are slightly curved like an S. 4. The *articular processes*, from the first to the tenth vertebra, gradually contract and approach the median line; in the succeeding vertebræ they, on the contrary, increase, and become concave and wider apart from those of the opposite side. 5. The volume of the *transverse processes* and the size of their diarthrodial facets, diminish from before to behind. In the three first vertebræ this facet is concave; in the first nine the articular facet looks outwards and backwards, while the facet on the body looks forwards; in the last the two facets are directed forwards. These two facets are generally confounded in the seventeenth and eighteenth vertebræ. The first dorsal vertebra much resembles the prominens; it is distinguished from it, however, by the presence of four

Fig. 19.



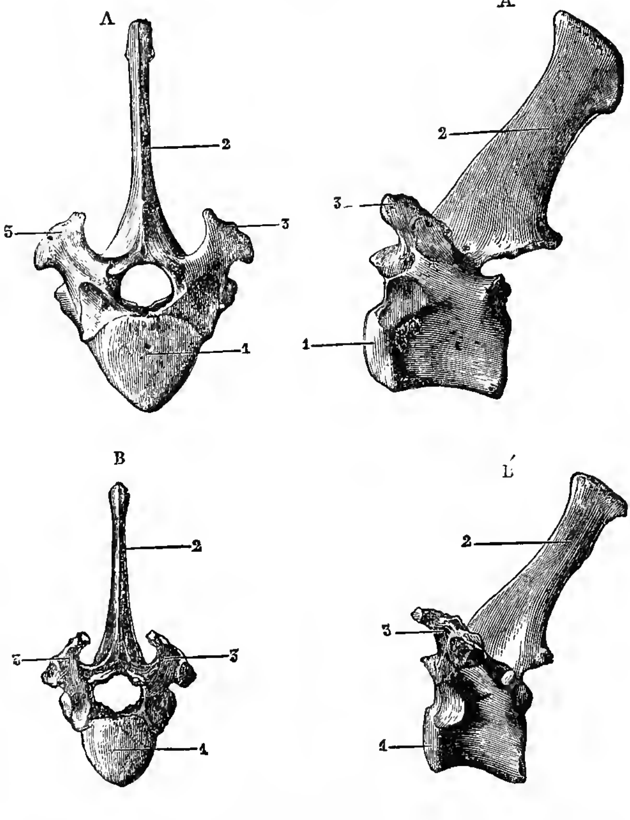
MIDDLE DORSAL VERTEBRA OF THE HORSE, VIEWED FROM THREE TYPICAL LINES.

The first line, A B, passes from before to behind by the most salient point of the transverse process, intersecting the middle of the lateral facet intended for the tuberosity of the rib, and of the cavity on the border of the posterior articular surface of the body. Below is the intervertebral foramen, the spinous process, and the articular facets on the base of the latter. The line C D is tangent to the summit of the transverse process and head of the vertebra; it intersects the anterior articular processes. The line M N is horizontal, and tangent to the inferior face of the body.

diarthrodial facets on its extremities. It also differs from the other vertebræ by the shortness of its spinous process, which terminates in a point; by the size and the prominence of its articular processes; and by the depth of its notches. The last vertebra never has facets on the contour of its posterior cavity.

Ass.—Besides the smaller volume of the vertebræ, the following differential characters will serve to distinguish these bones in this animal: 1. The spinous processes, as far as the tenth vertebra, are a little more inclined backwards than

Fig. 20.



A DORSAL VERTEBRA OF THE HORSE AND ASS (THE ELEVENTH).

A, *Vertebra of the Horse (anterior face).* 1, Head; 2, spinous process; 3, 3, transverse processes.
B, *Vertebra of the Ass (anterior face).* Same description as for the horse.
A′, *Vertebra of the Horse (lateral face).* 1, Head; 2, spinous process; 3, transverse process.
B′, *Vertebra of the Ass (lateral face).* Same description as for the horse.

in the Horse, while the inclination forward of the latter is equally marked; the anterior part of the summit of the spinous process is in contact with a horizontal plane, when the three last vertebræ of the Ass are laid on their anterior portion. 2. From the first to the tenth, the summit of the transverse processes lies behind the margin of the anterior articular facets in the Ass, while it is beyond them from the fourth in the Horse. From the eleventh to the thirteenth, the projection of the transverse processes is equal to that of the anterior articular facets in the two species; then the processes become predominant in the Ass (Fig. 20, A′, B′, 3, 3), and they preserve this character to the eighteenth. 3. All the transverse processes are less oblique than those in the Horse; also the line which intersects, in the middle, the summit of these processes and their lateral articular facet, passes always in front of the posterior facet on the body; in the Horse, this line traverses the latter facet, except in the first and fifth vertebra (Fig. 20, A. B). 4. There are not seen on the nine last dorsal vertebræ of the Ass, the anterior articular facets ascending to the base of the spinous process, as usually occurs in the Horse. 5. Lastly, the notches of the intervertebral foramina are nearly always closed by a bony bridge in the Ass, and only rarely so in the Horse.

The dorsal vertebræ in the **Mule** and **Hinny** offer the same mixture of particular characters which are found in their parents; though it is not doubtful that the vertebræ of the Mule (Hinny) produced by the union of the female Ass with the Stallion Horse, more resemble the former than the latter, especially in the transverse processes.

Differential Characters in the Dorsal Vertebræ of other Animals.

A. **Ox.**—In the *Ox*, these thirteen bones are longer and thicker than in the Horse. Their spinous processes are larger and incline more backward; their transverse processes are very voluminous, and are provided with a convex facet from above to below; while their posterior notches are nearly always converted into foramina.

Considered individually, they are more slender in the middle than at the extremities. Their spinous processes diminish in width, especially at their summits, from the first to the eleventh vertebra, and widen again in the two last; they progressively increase in slope to the tenth, after which they become more and more upright; the first four are the longest, and are nearly the same in height; the others gradually decrease.

In the first four or five vertebræ, the articular facet of the transverse processes, while retaining its vertical convexity, is concave in an antero-posterior direction. This facet is always absent in the last vertebra, and sometimes even in the preceding one. The two bones terminating the dorsal region show, in addition, the articular processes disposed like those of the lumbar vertebræ.

B. **Sheep and Goat.**—The thirteen dorsal vertebræ of the *Sheep* and *Goat* are relatively less strong than those of the Ox; their spinous processes are not so wide, and their posterior notches are never converted into foramina.

C. **Camel.**—The dorsal vertebræ of the *Camel*, twelve in number, are remarkable for the length of their bodies, and the height and width of their spinous processes. The transverse processes are a little less detached than in the Ox, but they are very tuberous. The posterior notches are narrow, deep, and close to the base of the spinous processes; they do not form foramina. The convexity or concavity of the *articular surfaces of the body* diminishes from the first to the last bone; while the spinous processes increase in length and width from the first to the sixth, and diminish in the last six. These processes are much inclined from the third to the ninth; then they gradually become erect in the last three.

D. **Pig.**—The *Pig* has fourteen dorsal vertebræ, which, in their general disposition, are not unlike those of the Ox. As with that animal, the intervertebral foramina are double, each vertebral lamina being perforated laterally by an opening situated in front of the posterior notch. In addition, the vertebræ of the Pig present this peculiarity, that their transverse processes are generally traversed at the base by a single or multiple foramen, which communicates with the preceding.

With regard to the special characters proper to some of the vertebræ, these are, as with the other animals, very few, and may be described as follows: 1. The transverse processes of the four vertebræ preceding the last project but slightly. 2. In the fourteenth this process resembles those of the lumbar vertebræ. 3. The articular facet of the transverse process in the four last vertebræ is confounded with the anterior lateral facet corresponding to the head of the rib. 4. The articular processes of the last five vertebræ are arranged like those of the lumbar vertebræ; and the prominence formed by the tubercle on the outside of the anterior articular process replaces, to a certain degree, the transverse process of these vertebræ.

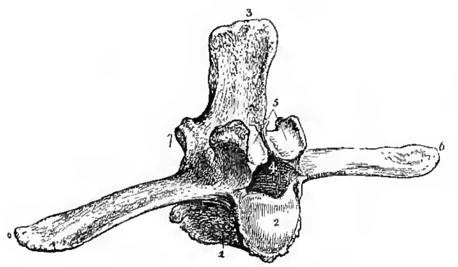
E. **Dog and Cat.**—These animals have thirteen dorsal vertebræ formed on the same model as those of the Horse; but their spinous processes are in general narrower and thicker. The *tenth* always has its spinous process vertical, triangular, and terminated in a sharp point. The *last three* have no posterior facets for the articulation of the heads of the ribs, and exhibit, in the conformation of their articular processes, the same disposition as the lumbar vertebræ. In the *Cat*, the transverse processes of the *three last* dorsal vertebræ are thin, sharp, and turned backwards; they never possess facets for the tuberosity of the ribs.

F. Rabbit.—The twelve dorsal vertebræ of this animal are similar to those of the Cat. But the spinous process of the *first nine* is thinner and more oblique, while that of the *three last* is higher and thinner than in the Cat. Besides, the transverse process is continued, in the Rabbit, by a triangular portion which increases the width of the vertebral lamina. The inferior face of the body is more hollowed in its middle portion, and the inferior crest is more salient than in the Cat.

3. Lumbar Vertebræ (Figs. 21, 22).

General Characters.—A little longer and wider than the dorsal vertebræ, which they resemble in the arrangement of their bodies, these vertebræ are characterized: 1. By their short, thin, and wide *spinous processes*, which are slightly inclined forwards, and are provided at their summits with a scabrous tubercle. 2. By their largely developed *transverse processes*, flattened above and below, and directed horizontally outwards.[1] 3. By the salient *anterior articular processes*, hollowed out on each side, and provided externally with a tubercle for insertion. 4. By their equally prominent *posterior articular processes*, rounded in the form of a half-hinge.

Fig. 21.



LUMBAR VERTEBRA (FRONT VIEW).

1, Body; 2, its articular face; 3, superior spinous process; 4, spinal foramen; 5, anterior articular processes; 6, 6, transverse, or costiform processes; 7, posterior articular process.

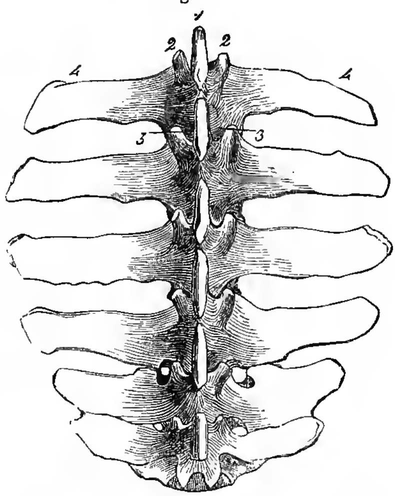
Specific Characters.—The characteristics which may serve to distinguish these vertebræ from one another, are derived from the body, and the spinous and transverse processes. 1. From the first to the last there is a progressive diminution in the vertical diameter of the bodies, and an increase in their transverse diameter. The inferior spine on the body becomes shorter and wider from the first to the last vertebra; in the six vertebræ it resembles an elongated triangle, the summit of which is directed forwards. 2. The spinous processes decrease in width from before to behind, and their anterior border becomes more and more concave; their summits are thickened and tuberculated in the three first, and thin and sloping forward in the three last. 3. The transverse processes are longer in the middle vertebræ than in those placed before and behind. The processes in the first and second vertebræ incline slightly backward; in the third they are more upright; and in the succeeding ones they are directed a little forward. In the last two they are remarkable for their thickness; in the fifth an oval-shaped articular facet is observed on their posterior border; in the sixth, two are present—one in front, corresponding to the preceding, and one behind, slightly concave, meeting a similar facet on the sacrum. The fourth and fifth vertebræ very often correspond, at their transverse processes, by means of analogous facets.

[1] Rudimentary ribs are sometimes found attached by ligaments to the extremities of the transverse processes (Lesbre).

According to Sanson, five is the natural number of lumbar vertebræ in the specific type of *African* Horses (see remarks on the Spine in General). The transverse processes in these animals also offer some peculiarities. Thus the increase in their length ceases at the *second*, and from this an almost insensible diminution occurs to the fifth. The transverse processes of the first lumbar vertebra are alone less inclined backward ; they are perpendicular to the direction of the body in the *second* and *third*, and inclined forward in the *fourth* and *fifth*.

The thoroughbred English Horse has sometimes five, sometimes six lumbar vertebræ, but in every instance the lumbar region is comparatively short (Cornevin).

Fig. 22.



UPPER SURFACE OF LUMBAR VERTEBRÆ.

1, Summit of spinous process ; 2, 2, anterior articular processes ; 3, 3, posterior articular processes ; 4, 4, transverse processes.

Ass.—The lumbar vertebræ in the Ass, five in number, are easily distinguished from those of the Horse by the characters special to their spinous and transverse processes, and articular tubercles.

1. The spinous processes are proportionately longer that those of the Horse, and they are also more inclined forward. If their bodies rest on a horizontal plane, and if a line be drawn tangent to the posterior border of the spinous process, an acute angle is always obtained at the point of junction of the line and plane ; but if this be done with the vertebræ of the Horse, there is at least a right angle.

2. The transverse processes increase in length from the *first* to the *second* ; they are nearly equal in the *second* and *third*, and decrease suddenly in the *fifth*. They are usually inclined downwards ; their posterior border and superior face, near the body, are marked by a vasculo-nervous furrow, which is scarcely visible in the Horse. Finally, it is not rare to find no inter-transverse articulation between the two last.

3. The most important differential character is observed in the articular tubercules. The diarthrodial facets are surmounted by a flat tongue of bone, which is projected outwards in the direction of the summit (see Fig. 23, A, B, 4, 4). This piece gradually becomes lower from the *first* to the *fifth* vertebra ; in the *first*, it projects beyond the articulation by more than one-fourth of an inch, and, up to a certain point, resembles the condition observed in the Rabbit or Dog.

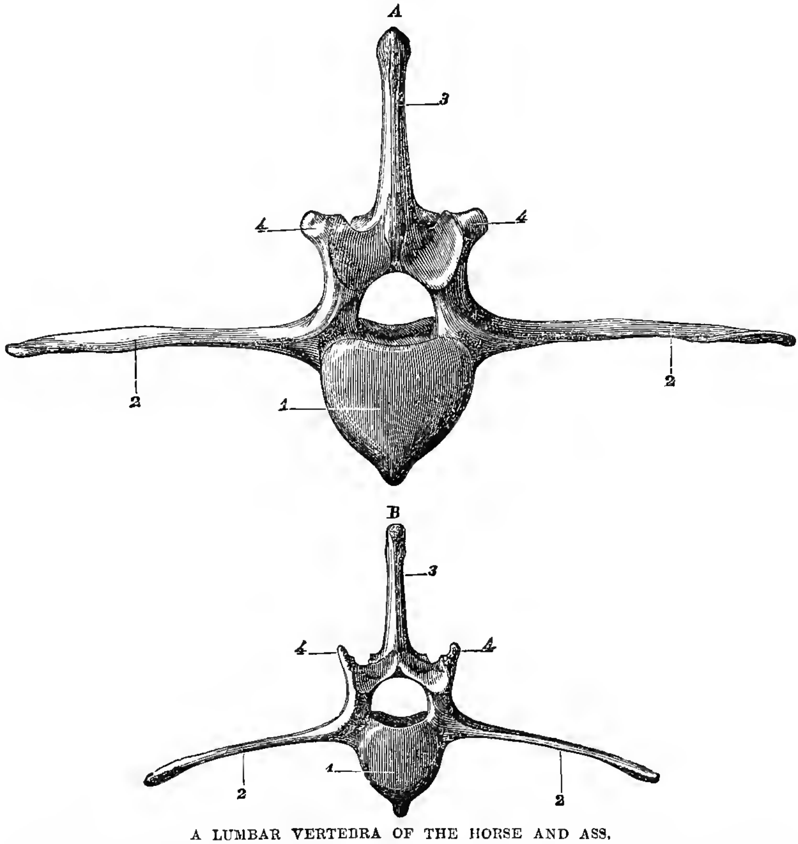
In the **Mule** there are sometimes six, sometimes only five, lumbar vertebræ. These have the spinous and transverse processes somewhat as in the Horse ; their articular tubercles resemble those of the Ass.

In the **Hinny,** of which opportunity has rarely been had for study, Goubaux and ourselves have found five lumbar vertebræ, which, in their shape, much resembled those of the Ass.

Differential Characters in the Lumbar Vertebræ of other Animals.

A. Ox, Sheep, and **Goat.**—The six lumbar vertebræ of the *Ox* are longer and thicker than those of the Horse. The transverse processes are also generally more developed, are concave on the anterior border, convex on the posterior, and incline slightly downward, with the exception of the two first, which remain nearly horizontal. They increase in length from the *first* to the *fourth* vertebra; in the latter and the *fifth*, they are nearly of the same dimensions; in the *last* they suddenly become shorter. Their width gradually decreases from before to behind. In the *fifth* and *sixth* vertebræ, these processes have no articular facets between them and the sacrum, these being only met with in Solipeds. The articular processes are prominent, and further removed from the median line as they belong to posterior vertebræ.

Fig. 23.



A LUMBAR VERTEBRA OF THE HORSE AND ASS.

A, *Lumbar vertebra of the Horse (anterior face).* 1, Head; 2, 2, transverse processes; 3, spinous process; 4, 4, articular tubercles.
B, *Lumbar vertebra of the Ass (anterior face).* Same description as for the horse.

In the *Goat* the transverse processes are more inclined downwards.

In the *Sheep*, on the contrary, the processes of the six or seven vertebræ ascend towards their extremities.

B. **Camel.**—Apart from number, which is seven, the lumbar vertebræ of this animal offer nearly the same features as those of the Ox.

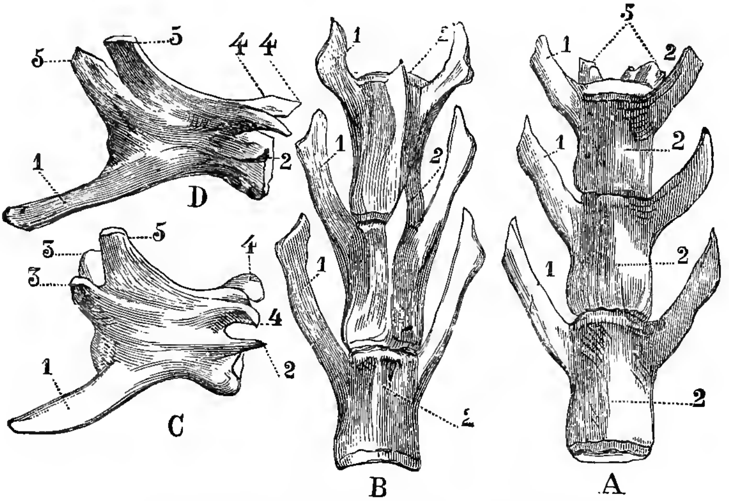
C. **Pig.**—The lumbar vertebræ of the *Pig* greatly resemble those of ruminant animals. It commonly happens that seven are met with; but in this case the supplementary vertebra is generally a sacral one. It is not denied, however, that seven lumbar vertebræ may exist in the Pig, along with the normal number of sacral vertebræ.

D. **Dog** and **Cat.**—In the *Dog* and *Cat*, the lumbar vertebræ, seven in number, are remarkable for their strength, due to their length, thickness, and the development of the eminences for insertion. The spinous process is low, and becomes acute in the last vertebra.

The transverse processes incline very much forward and downward; they become longer from the first to the second-last bone; in the latter they become contracted, and in the seventh vertebra they are still more diminished, and terminate in an obtuse point. The tubercle of the anterior articular process is extremely prominent, and the posterior notches are surmounted by a small, very acute prolongation, directed backwards, which becomes more developed towards the anterior vertebræ. This small prolongation exactly represents the transverse process of the dorsal vertebræ.

E. **Rabbit.**—They are stronger than those of the Cat, and the first three have on the lower surface of their bodies a very salient crest, which simulates a real inferior spine; the others have a median crest which gradually decreases towards the last bone. The tubercle surmount-

Fig. 24.



LUMBAR VERTEBRÆ OF THE CAT AND RABBIT.

A, *Second, third, and fourth lumbar vertebræ of the Cat (inferior face).* 1, 1, 1, Transverse processes; 2, 2, 2, crest on the inferior face of the body; 3, articular tubercles of the first vertebra.
B, *Second, third, and fourth lumbar vertebræ of the Rabbit (inferior face).* 1, 2, Same signification as in preceding.
C, *Third lumbar vertebra of the Cat (lateral face).* 1, Transverse process, anterior prolongation; 2, ditto posterior prolongation; 3, 3, anterior articular tubercles; 4, 4, posterior ditto; 5, spinous process.
D, *Third lumbar vertebra of the Rabbit (lateral face).* 1, Transverse process, anterior prolongation; 2, ditto posterior prolongation; 3, anterior articular tubercle; 4, 4, posterior articular tubercles; 5, spinous process.

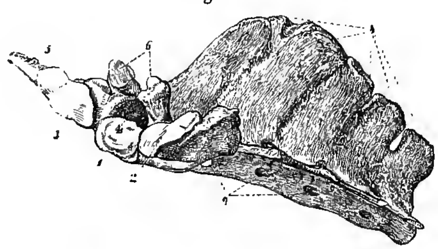
ing the posterior notches is more developed than in the Cat. The spinous process is prolonged backward by a translucent bony plate, which disappears in the last two. The anterior articular tubercles are more developed, more erect, and nearer the median line, than in the Carnivora. Lastly, the transverse processes are relatively longer, and those of the first are remarkable for the notched enlargement they offer at their free extremities.

4. Sacrum (Fig. 25).

The sacrum results, as already stated, from the consolidation of five vertebræ. This single bone articulates, in front, with the last lumbar vertebra; behind, with the first coccygeal bone, and on the sides with the ossa innominata. It is triangular, flattened above and below, and from before to behind describes a slight curve upwards. It offers for study a *superior* and an *inferior face*, two *borders*, a *base*, a *summit*, and a *central canal*—the extension of the spinal canal.

Faces.—The *superior face* presents, on its middle, the spinous processes of the sacral vertebræ, which together constitute what is called the *sacral* or *supersacral spine.* These processes are united at their base only, and remain isolated for the remainder of their extent; they all incline backwards and terminate, with the exception of the first, by a tuberous summit, which is often bifid; their length diminishes from the second to the fifth bone. On each side of the sacral spine exists a groove, at the bottom of which are four openings—the *super-sacral foramina.* These orifices open into the spinal canal, and communicate with four analogous, but wider apertures, pierced at the inferior face of the bone, and for this reason named the *sub-sacral foramina.* The *inferior face* is smooth, and shows traces of the primitive separation of the vertebral bodies; the sub-sacral foramina, which represent, with the corresponding super-sacral openings, the intervertebral foramina of the other regions of the spine, are observed on this surface.

Fig. 25.



LATERAL VIEW OF SACRUM.

1, Articular surface of body; 2, 3, articular surfaces corresponding to those on the transverse processes of the last lumbar vertebra; 4, spinal foramen; 5, auricular facet; 6, anterior articular processes; 7, inferior or sub-sacral foramina; 8, superior spinous processes; 9, summit or coccygeal extremity.

Borders.—The *two borders*, thick and concave, form, posteriorly, a rugged lip; in front, they present an irregular surface inclining obliquely from above to below, from within outwards, and from before to behind. This surface, which is intended for the articulation of the sacrum with the ossa innominata, is divided into two parts: one, the inferior—named in Man the *auricular facet*—is slightly undulated and diarthrodial; the other, the superior, serves for ligamentous insertions.

Base.—This offers: 1. On the median line, the anterior orifice of the sacral canal, and the anterior articular surface of the body of the first sacral vertebra, which is oval and slightly convex. 2. On the borders, the articular processes and anterior notches of this vertebra, as well as the elliptical and somewhat convex facets which bring it into contact with the transverse processes of the last lumbar vertebra.

Summit.—The summit, thrown back, presents: 1. The posterior orifice of the sacral canal. 2. The posterior articular surface of the body of the last sacral vertebra. 3. The vestiges of the articular processes and posterior notches of that vertebra.

Sacral canal.—This is the portion of the spinal canal which is channeled out of the sacrum; it is triangular, and diminishes in width from before to behind.

The sacrum of the **Ass** much resembles that of the Horse; nevertheless, it is possible to distinguish it by the shape of the articular tubercles of the first sacral vertebræ, which resemble those of the articular tubercles of the lumbar region, and the traces those tubercles have left between the sacral vertebræ, especially between the first.

Differential Characters in the Sacral Vertebræ of other Animals.

A. **Ox.**—The sacrum of the *Ox* is more voluminous and curved than that of the Horse. The spinous processes are entirely consolidated, and are surmounted by a thick rugged lip;

they are bordered at their base and on each side by a ridge that represents the rudiments of the articular processes. The lateral borders are sharp and bent downwards. The surfaces that serve to unite the sacrum to the ossa innominata have a somewhat vertical direction. There are no lateral facets on the base of the bone, for the union of the sacrum with the transverse processes of the last lumbar vertebra.

B. **Sheep and Goat.**—In the *Sheep* and *Goat*, the sacrum is shorter; sometimes the consolidation of the spinous processes is late, or never occurs.

C. **Camel.**—Sacrum short and composed of four vertebræ: broad and curved on its inferior face. The spinous processes, rather low, are strong and free throughout their extent. The auricular facets are cut very obliquely.

D. **Pig.**—This is formed by four vertebræ, which are a long time in becoming fused together; and it is often difficult to discover where the sacrum ends and the coccyx begins.[1] The spinous processes are entirely absent. The vertebral laminæ are not consolidated; so that the spinal canal is half cut through in its upper portion, as in the cervical region; this canal is also much compressed above and below.

E. **Dog** and **Cat.**—The three vertebræ which form the sacrum of Carnivora are early consolidated. The sacral spine constitutes a thin sharp ridge, while the lateral surfaces for articulation with the ossa innominata are turned quite outwards, and are nearly vertical.

F. **Rabbit.**—Relatively longer than that of Carnivora, the sacrum of this animal is remarkable for the presence of four vertebræ, the spinous processes of which are isolated from each other.

5. Coccygeal Vertebræ.

The *coccygeal region*, or *coccyx*, comprises from fifteen to eighteen degenerate vertebræ, which gradually diminish in thickness from the first to the last. In the first three or four, nearly all the characteristics of true vertebræ are found; they show a vertebral foramen, a body, a spinous process, and transverse processes, directed backwards; the articular processes only are altogether absent. In the succeeding vertebræ, these characters become effaced; the vertebral laminæ do not join completely, and the vertebral canal is only a simple groove, which, gradually decreasing in depth, at last entirely disappears. The insertion eminences also become less salient, and the coccygeal vertebræ are soon reduced to small bony cylinders, narrow in the middle and wider at both extremities, with a convex articular surface at each end (except the last, which has only one articular surface). These small cylinders—the last traces of the vertebral bodies—are each developed from three centres of ossification; they are very spongy and light. The first coccygeal vertebra is frequently consolidated with the sacrum in aged animals.

Differential Characters of the Coccygeal Bones in other Animals.

A. **Ox, Sheep,** and **Goat.**—In proportion, the coccygeal vertebræ of ruminants are stronger and more tuberous than those of the Horse. The anterior articular processes exist in a rudimentary condition.

B. **Camel.**—Fifteen to eighteen in number, they are not so strong and are less tuberous than in the Ox. The first six are channeled by a triangular canal.

C. **Pig.**—These vertebræ in the *Pig* are more particularly distinguished by the presence of articular processes, by means of which the foremost bones correspond with each other.

D. **Dog** and **Cat.**—In these animals, the vertebræ of the coccyx are very strong and tuberous. The first five or six are as perfect as the true vertebræ, and comport themselves in every respect like them. The last are small V-shaped bones, which M. Goubaux has described by the name of *hypsiloid bones*.

E. **Rabbit.**—The coccyx of the *Rabbit* is analogous to that of the Cat.

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[1] This can always be made out, however, by consulting the disposition of the articular processes. Thus, in the sacral vertebræ these eminences—if we except the anterior ones of the first and the posterior of the last—never exist except in a rudimentary state; while in the other five coccygeal vertebræ they reappear with all their characters.

The Spine in General.

The vertebral column has now to be considered in its entirety, and examined successively in its *superior face*, its *inferior face*, its *lateral faces*, and its *spinal canal*. Afterwards its direction and mobility will be noticed.

Superior surface.—This presents, on its median line, the series of spinous processes. But little salient in the cervical region, these eminences are much developed in the dorsal and lumbar, where they constitute a long crest—the *dorso-lumbar spine*, as well as in the sacrum, where they form the *sacral spine*. They soon disappear in the coccygeal vertebræ. Outwards, and on each side of these processes, is seen a succession of tubercles for insertion, represented in the cervical and lumbar vertebræ by articular processes, and in the dorsal vertebræ by the superior or rugose portion of the transverse processes. These tubercles are disposed in line, and separated from the spinous processes by a channel designated the *vertebral groove*, which is more or less deep and wide. It is on these, and on the spinous processes, that the extensor muscular fasciculi of the spine receive the greater portion of their fixed or movable insertions.

Inferior surface.—Wide at the neck, this surface becomes narrow in the dorsal region, to be again widened at the lumbo-sacral region, and once more contracted at the coccyx. Crests more or less developed, which divide the vertebral bodies into two lateral portions, right and left, are remarked.

Lateral surfaces.—These offer for study the thirty-six intervertebral foramina, through which the spinal nerves pass. They exhibit besides, in the neck, the transverse processes; in the back, the external facets of these processes, and the intervertebral facets, all destined to sustain the heads of the ribs; on the loins, the transverse or costiform processes. It may be remarked that the ribs and the transverse processes of the neck and loins furnish points of insertion to the powerful muscles which produce the lateral movements of the spine. In the sacrum, the lateral faces are formed for the articulation of the spine with the ossa innominata.

Spinal canal.—This canal communicates, in front, with the cranial cavity. Very wide in the atlas, for the reception of the odontoid process and to permit the rotatory movements of the head without injury to the spinal cord, this canal suddenly diminishes in the axis. It again dilates at the termination of the cervical region and the commencement of the dorsal; there the spinal cord presents a greater volume, and the movements of the spine are very extensive. Towards the middle of the back, the spinal canal offers its smallest diameter; it widens from this part to the lumbo-sacral articulation; after which it contracts rapidly, and disappears altogether near the fourth or fifth coccygeal vertebra. The lumbo-sacral dilatation coincides with the enlargement of the cord in this region, and with the enormous quantity of nerves lying beside it.

Direction of the Spine.—The spine does not extend in a straight line from the head to the posterior extremity of the body. If it is followed from the caudal extremity—which is free and looks downwards—to the anterior extremity, it will be observed that it passes upwards and forwards, forming a convex inflexion corresponding to the roof of the pelvis. In the lumbar and posterior half of the dorsal region, it is nearly horizontal and rectilinear; thence it descends to the cervical region, where it again rises and forms two curves—one, posterior, bending upwards, the other anterior, passing downwards. This direction of the spine gives it the form of a console.

Mobility of the Spine.—In the cervical region, the almost total absence of spinous processes, the great development of the articular processes, and the very short curve described by the surfaces of contact of the vertebral bodies, allow the spine very extensive and varied movements. In the dorsal region, however, these movements are very limited, the spinous processes and the costal arches preventing the play of the vertebræ on each other. In the lumbar region, the spine can be flexed and extended more than in the dorsal; but its lateral movements are quite as restricted, owing to the presence of the transverse processes and the reciprocal union or dovetailing of the articular processes. Lateral motion is even rendered impossible in the posterior half of this region, from the manner in which the transverse processes are adapted to each other. It may be remarked, however, that this disposition singularly favours the integral transmission of the propulsive efforts communicated to the trunk by the posterior extremities.

The sacral vertebræ, having to afford the ossa innominata a solid fixed point, could not preserve their independence and mobility if they were like the other vertebræ; they are consequently consolidated into a single piece, which fulfils all that is required of it in this respect. In the coccyx the spine again recovers its mobility, and to an extent more marked than elsewhere; the bones, articulating with each other by means of convex surfaces, and having no long processes at their extremities, are placed in the best possible conditions for effecting varied and extensive movements.

Varieties in the Vertebral Column.

To anatomists, the bones of the spine have frequently offered curious varieties in their shape and number.

1. *Shape.*—Goubaux has observed varieties of this kind in the last two cervical vertebræ of the Horse. In one instance, the sixth had the transverse process biscuspid on the left and tricuspid on the right. This anatomist has collected several similar examples. Husson has found the sixth cervical vertebra with a prolongation deficient in the transverse processes; and the seventh, on the contrary, with an additional prolongation.

The dorsal vertebræ have also exhibited varieties in shape. Daubenton has referred to the skeleton of an Ass, in which the last vertebra had on one side only a transverse process like that of the lumbar vertebræ. We have seen this variation in the Horse.

In the lumbar region, Goubaux has noticed—as we have done—the fourth and fifth vertebræ sometimes articulating by their transverse processes; the articulations may even be fused. Sometimes the transverse processes of the first lumbar vertebra articulate at their base with the body of the bone, and become floating ribs.

Thomas has remarked an interesting variation in the sacrum. He found in the Sheep a long, costiform, transverse process on one of the sides of the first sacral vertebra. The last vertebra in this region sometimes shows, in the Dog—either to the right or left, or on both sides at the same time—one or more articular facets on the transverse processes, uniting with similar facets on the first coccygeal bone (Goubaux).

2. *Number.*—For a long time, instances have been accumulating of variations in the number of bones in the spine; but they do not form a very imposing array, probably because it is difficult to observe them without making a special and attentive study of the subject.

These variations have been noted in all the regions of the vertebral column, though they are rare in the cervical region. Sometimes they consist in a diminution, sometimes in an increase, in the number of the vertebræ.

a. So far as it is known, a decrease in the number of the cervical vertebræ in the domestic animals has not been observed. Goubaux has sometimes met with eight cervical vertebræ, though, as the eighth offered relations with the first rib, he was disposed to place it in the dorsal region. In this case the anomaly was in the number of bones in the spine.

b. The dorsal region is more frequently abnormal. Bourgelat and Rigot have dissected Horses which had only seventeen dorsal vertebræ. Goubaux and ourselves have seen similar instances, though the length of the animals afforded no suspicion of modification in their spines. It is certainly more common to see the number of dorsal vertebræ increased to nineteen, as is proved by the observations of Bourgelat, Rigot, Husson, Goubaux, and our own.

This increase is observed also in the asinine species. We have the skeleton of an Ass in which there are twenty ribs on each side, and therefore twenty dorsal vertebræ. In the Ox, fourteen dorsal vertebræ have been found.

c. The lumbar region is still more frequently modified. The Horse at times has only five lumbar vertebræ (Daubenton, Chauveau, Goubaux, Sanson, and several German anatomists); the Ass only four (Goubaux). In the other animals—the Dog, for example—an increase in number has been remarked; Girard has seen eight lumbar vertebræ, instead of seven. Goubaux and ourselves have on several occasions seen seven lumbar vertebræ in the Sheep.

d. The sacrum has often one or two pieces more in old subjects, due to the fusion of the first or second of the coccygeal vertebræ with its posterior extremity. At other times, the supernumerary piece is situated at the base. Rarely is the number of sacral vertebræ diminished; Goubaux has only met with one instance in which there were four sacral vertebræ in the Horse.

e. The number of coccygeal bones is extremely variable; and in order to be convinced of this, one has only to look at the tables drawn up by anatomists. Nevertheless, it is certain that the normal number is never less than seven or eight, as Bourgelat stated in the first edition of his *Anatomie.*

To resume, it is seen that all the regions of the spine may offer variations in the number of vertebræ, and that these variations—rare between the neck and the back—are, on the contrary, frequent at the two extremities of the lumbar region. When the bones are deficient, the diminution is only apparent—that is, the vertebra which is absent in one region is carried to the adjoining region. It frequently happens, for instance, when a lumbar vertebra is missing, that the sixth is united to the sacrum; or when there are nineteen dorsal vertebræ, there is one less in the lumbar region. It is not always sufficient to examine the regions contiguous to the one which is modified, to gain an exact notion as to the modification. In fact, a change in the number of vertebræ in a region may be compensated for by an alteration in a distant region. In the museum of the Lyons school, there is the skeleton of an Ox in which there are fourteen dorsal vertebræ, with the normal number of cervical, but only four sacral. We also possess the skeleton of a Horse which has seven lumbar vertebræ, with the normal number in the other regions, though the seventh bone is certainly the first sacral, as it has all its characteristics; and with regard to the fifth sacral bone, this evidently comes from the coccygeal region. In the first skeleton, the increase in the dorsal region has therefore been *compensated* for by a decrease in the sacral region ; and in the second, the augmentation in the lumbar region has been compensated for by a diminution in the coccygeal region.

These transpositions occur more especially on the confines of the dorso-lumbar and lumbo-sacral regions.

But the increase or decrease in the normal number of vertebræ is sometimes absolute. Goubaux and Husson have found, in the Horse, nineteen dorsal vertebræ with the normal number of the other vertebræ. The Ass with twenty ribs already mentioned, had the usual number of vertebræ in the other regions. The first-named anatomist has counted, under the same conditions, seven lumbar vertebræ in the Sheep. Hering, Rueff, Leyh, Sanson, etc., have found five lumbar vertebræ in the Horse, without any modifications in any other parts of the vertebral column. Sanson has even remarked, that in several oriental Horses there are generally only five lumbar vertebræ. The presence of this anomaly is always allied to a particular shape of the cranium and face. In the estimation of Sanson, these characters are so important that they serve to distinguish specific types. The specific type with five lumbar vertebræ is peculiar to north-east Africa, probably Nubia.

It is not intended in this place to discuss the opinions of Sanson and the value of his specific types, but merely to remark that the number of vertebræ is very liable to variation in each region of the spine, and that these variations are even so frequent in animals of the same origin, that it would be perhaps premature to attribute to the number of vertebræ in a given region the value of an absolutely specific character.

It has been attempted to explain these variations by an ancestral influence, or by the influence of surroundings and exercise. But why might they not be the consequence of irregularities in the fusion of the nuclei which constitute the vertebral column of the fœtus ? Fol has observed that at the fifth week the human embryo has thirty such pieces, and that at the sixth week the thirty-eighth, thirty-seventh, and thirty-sixth vertebræ have become one, while the thirty-fifth has no longer perfect limits—so that an embryo measuring nineteen millimetres has only thirty-four vertebræ. The spine of the embryo is composed, therefore, of a larger number of pieces than that of the adult. The reduction in number is due to fusions ; consequently, it is reasonable to admit the possibility of variations in the extent of these fusions and the places where they may occur. (For further details, see the Memoirs of Goubaux and Sanson, in Robin's *Journal de l'Anatomie de la Physiologie*, 1867 and 1868.)

Comparison of the Vertebral Column of Man with that of the Domesticated Animals.

The vertebral column of Man is composed of twenty-nine bones: twenty-four vertebræ, the sacrum, and four pieces constituting the coccyx. The twenty-four vertebræ are thus distributed:

Cervical vertebræ	7
Dorsal „	12
Lumbar „	5

In all these vertebræ, the bodies are slightly excavated at the two extremities, while in the domesticated animals, the superior or anterior is convex, and the inferior or posterior concave.

1. *Cervical vertebræ.*—These are wide and short. The spinous processes are moderately developed and bifid at their summits; the transverse processes are also divided into two branches—a posterior and an anterior.

2. *Dorsal vertebræ.*—In these vertebræ, the bodies increase in thickness from the first to the last. In the first as well as in the last dorsal vertebræ, the spinous process is almost

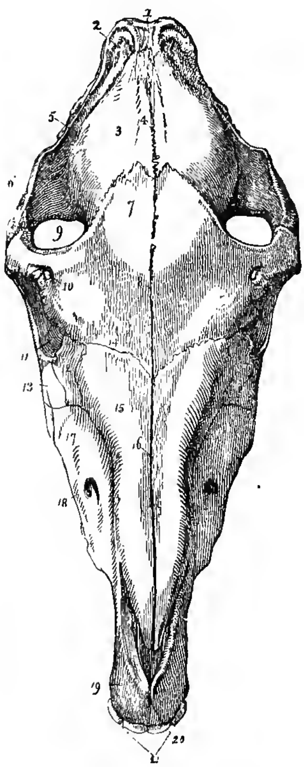
immediately directed backwards; in the middle portion of this region these processes are very obliquely directed downwards and backwards.

3. *Lumbar vertebræ.*—The lumbar vertebræ are the strongest bones in the spine, and their bodies are nearly as thick as those of the larger domesticated animals. This enormous development of the lumbar vertebræ in Man is related to his position as a biped. In the fifth, the lower face of the body is cut very obliquely backwards and upwards, and the transverse processes are more voluminous than those of the other lumbar vertebræ.

4. *Sacrum.*—The sacrum is formed by the union of five pieces. It is very concave from above to below and before to behind. In becoming united to the lumbar region, it forms a salient angle in front, to which has been given the name of *promontory* or *sacro-vertebral angle.* The sacral spine is continuous or interrupted, according to the subject; it is always bifid inferiorly.

5. *Coccygeal vertebræ.*—These are little bones or flattened tubercles, four in number, rarely five, and usually consolidated. The coccyx is conical in shape. Its base shows two processes directed upwards, which are called the cornua of the coccyx. Its summit is often deviated to the right or left.

Fig. 26.



HORSE'S HEAD (FRONT VIEW)

1, Occipital tuberosity; 2, origin of the mastoid crest; 3, parietal bone; 4, saggital suture; 5, junction of the parietal and temporal bones; 6, zygomatic arch; 7, frontal bone; 8, frontal suture; 9, temporal fossa; 10, supra-orbital foramen; 11, 12, lachrymal bone; 13, malar bone; 14, nasal border of frontal bone; 15, nasal bone; 16, suture of nasal bones; 17, super-maxillary bone; 18, infra-orbital foramen; 19, anterior, or pre-maxillary bone; 20, foramen incisivum; 21, incisor teeth (young mouth).

Article II.—The Head (Fig. 26).

The head is a large, bony, quadrangular pyramid, elongated from above to below, suspended by its base to the anterior extremity of the spine. Its direction varies with the attitudes of the animal, but we will suppose it, for convenience of description, to be nearly vertical. It is formed of a great number of particular bones, which are only distinct from one another in very young animals; for well before the adult period is reached, the majority of the bones are united and cannot be separated.

The head is divided into two parts: the *cranium* and the *face.*

Bones of the Cranium.

The *cranium*, or upper part of the head, is composed of seven flat bones, five of which are single: the *occipital*, *parietal*, *frontal*, *sphenoid*, and *ethmoid;* one only, the *temporal*, is double. These bones circumscribe a central cavity, the *cranial*, which communicates behind with the spinal canal, and lodges the principal portion of the nervous centres—the brain.

1. Occipital Bone (Fig. 26, 1).

The *occipital* bone occupies the superior extremity of the head, which it supports from the anterior extremity of the spine. This bone is very irregular in its form, and is bent at a right angle in front and behind. It has an *external* and an *internal face*, and a *circumference* which brings it into contact with the adjoining cranial bones ; the latter is subdivided into two *anterior lateral borders*, two *posterior lateral borders*, an *anterior* and *posterior salient angle*, and two *lateral re-entering angles*.

Faces.—The *external face* is divided into three portions by the double flexure of the bone : one looks forward, another upward, and the third backward. It exhibits :—1. On the median line, and from before to behind : *a*, an antero-posterior ridge which constitutes the origin of the parietal ridges, to be mentioned hereafter ; *b*, a transverse, voluminous, and very prominent eminence, marked posteriorly by deep imprints, with a medium projection named the *cervical tuberosity ;* this is the *external occipital tuberosity* which, in the Horse, corresponds at the same time to the *superior curved lines* of the occipital bone of Man. This protuberance forms the culminating point of the head, and divides the anterior and superior parts of the external face of the bone ; *c*, the *occipital foramen* (*foramen magnum*), a large orifice that passes through the bone at the posterior flexure, and establishes a communication between the cranial cavity and spinal canal ; *d*, the external surface of the *basilar process*—a narrow and thick prolongation formed by the bone as it passes to meet the sphenoid . this surface is convex laterally. 2. On the sides : *a*, A sharp crest which prolongs, laterally, the superior curved lines, and descends on the middle of the lateral anterior border, to be continued with the superior root of the zygomatic process and the mastoid crest of the temporal bone ; *b*, Linear imprints, parallel to the latter, and prolonged on the base of the styloid process : they are destined for the insertion of the small oblique muscle of the head, and represent the *inferior curved lines* of the occipital bone of Man ; *c*, Within these imprints is a slightly roughened cavity for the insertion of the posterior recti muscles ; *d*, The two *condyles*—articular eminences with a double convexity, one superior, the other inferior : these eminences are situated on each side of the occipital foramen (*foramen magnum*), and correspond to the anterior cavities of the atlas ; *e*, More outwards are the two *styloid* (*paroccipital*) *processes*, or *jugular eminences*—long projections flattened on each side, terminated in blunt points, directed backwards, and separated from the condyles by a deep space, the *stylo-condyloid notch ; f*, Under the condyles is the *condyloid fossa*—a smooth depression, pierced at the bottom by the *condyloid foramen*, which penetrates the cranium.

The *internal face* of the occipital bone is concave, and shows : behind, the foramen magnum ; above, an uneven surface, which forms the roof of the cerebral cavity ; below, the superior face of the basilar process, slightly hollowed into a groove ; on the sides, the internal orifice of the condyloid foramen.

Circumference.—The *anterior lateral borders* are thick, and are united by suture with the parietal bone, and with the tuberous portion of the temporal bone by the harmonia suture. The posterior lateral borders are sharp, and constitute the sides of the basilar process ; each concurs in the formation of the *occipito-spheno-temporal* hiatus, also termed the *foramen lacerum basis cranii*—a vast irregular opening, extending from above downwards, penetrating the cranium, and divided by a ligament, in the fresh state, into two portions, one inferior, the *anterior foramen lacerum*, the other superior, the *posterior foramen lacerum*. The *anterior angle*, which is dentated, is dovetailed into the parietal bone. The *posterior angle* is very thick, and forms the summit of the basilar process ; it is united by suture with the body of the sphenoid. The *lateral re-entering angles*, or *jugular notches*, correspond to the point where the bone is bent posteriorly ; they separate the anterior lateral from the corresponding posterior lateral border, and are occupied by the petrous portion of the temporal bone.

Structure.—The occipital bone contains much spongy substance.

Development.—It is developed from four centres of ossification; one, the anterior, is single, and forms the occipital tuberosity; another, the posterior, also single, forms the basilar process; the other two are pairs, and comprise each a condyle, with a styloid process and the corresponding condyloid foramen.

The occipital bone in the **Ass** is distinguished by the prominence of the external occipital tuberosity (see the Head in General), by the depth of the groove (mastoid) which courses over the outer face of the styloid process, and by the articular surface prolonged to the origin of the basilar process, which constricts it in a circular manner.

Differential Characters in the Occipital Bone of other Animals.

A. **Ox.**—The occipital bone of this animal does not show any anterior elbow, neither does it form a portion of the anterior part of the head. The external occipital tuberosity is obtuse, and gives rise on each side to the superior curved lines.

The styloid processes are short and much bent inwards. The basilar process, wide, short, and thick, has a groove in the middle of its external face; this groove is sometimes absent in the Sheep and Goat.

The condyloid foramina are double, sometimes triple; the superior foramen does not pass directly into the cranium, but goes to a vast conduit that opens behind on the lateral margin of the occipital foramen, and which terminates in front by two orifices, one entering the parieto-temporal canal, the other opening on the external surface of the bone. The foramen lacerum is divided into an anterior and posterior foramen, by the mastoid portion of the temporal bone.

B. **Sheep** and **Goat.**—The inner tuberosity is only marked by a slight prominence of the internal plate of the bone. In the occipital bone of these animals are found the peculiarities noted in that of the Ox; the groove on the basilar process is sometimes absent, and in the Sheep the superior curved lines are very salient and occupy the summit of the head. This feature is still more marked in the Goat, and also more in the Cervine species, in which this bone somewhat resembles that of the Horse.

C. **Camel.**—The bone shows a double angle as in Solipeds. In its anterior and superior portions it resembles that of the Horse, and in its posterior portion that of the Ox. The crest, which constitutes the origin of the parietal crests, as well as the superior curved lines, are thin, sharp, and very high. The styloid processes are short, wide, thick, and articulated by harmonic suture with the tuberosity of the temporal bone. The superior curved lines are scarcely marked in young animals.

D. **Pig.**—The occipital bone in this animal is not bent anteriorly; but the transverse protuberance representing the curved lines forms, nevertheless, as in the Horse, the summit of the Head. This eminence, which is excavated on both sides on the posterior face, unites in front with the parietal bone, which abuts on the occipital at an acute angle. There is no external occipital protuberance, properly speaking, and the styloid processes are very long and directed downwards.

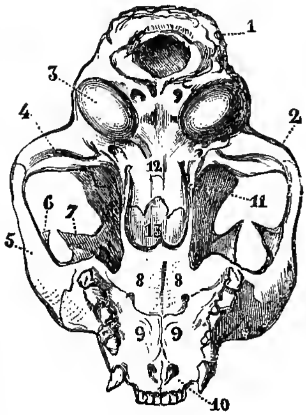
E. **Carnivora.**—The external occipital tuberosity is very strong and high. The external occipital crest is absent or little marked; the styloid processes are short. The foramen lacerum is divided into two portions by the mastoid process, and the basilar process is wide, long, and thick, and hollowed on the side by a channel that joins a similar one in the temporal bone to form a large venous canal. This last communicates, behind, with the posterior foramen lacerum, and opens, in front, in the cranium, where it is continuous with the cavernous groove of the sphenoid. The anterior angle forms a very marked prominence, which is deeply fixed into the parietal bone, and partly constitutes the internal occipital process of that bone. The latter does not show the lateral excavations at its base; they are found lower, towards the summit of the petrous bone, on the sides of the occipital. The parieto-temporal canals are, nevertheless, continued to the base of the process, which they traverse to open into its interior. In the most intelligent breeds, the occipital foramen is deeply notched above (Faure).

2. The Parietal Bone (Fig. 26).

The *parietal* is a wide and thin bone, very much arched to form the roof of the cranial cavity. It is bounded above by the occipital bone, below by the frontal, and laterally by the two temporal bones. It offers for study an *external* and *internal face*, and a *circumference* divided into four regions or *borders*.

Faces.—The *external face* is convex. It exhibits two curved ridges with concavity directed outwards; these two crests, which are termed the *parietal ridges*, approach each other and unite superiorly, to be continued with the antero-posterior ridge of the occipital bone; below they diverge and proceed, one on each side, to join the supra-orbital process. They divide the surface of the bone into three portions: two lateral, which are rough and traversed by vascular channels, forming part of the temporal fossæ; the third, or middle, is plane, smooth, and of a triangular form, and covered by the skin. The *internal face* is concave, covered by digital impressions, and grooved by small vascular canals; it offers, on the middle line, and altogether above, the *parietal protuberance.* This trifacial and very salient projection presents at its base, on each side, an excavation elongated transversely, into which opens the parieto-temporal canal, and which lodges a venous sinus. It is continued, in front, by a median crest, which is often replaced by a slight groove—the *saggital furrow*, bordered by linear imprints. Two other ridges, resulting from the abutment of the lateral border of the bone against the anterior face of the petrous bone, rise from the sides of this eminence and descend to the sphenoid bone; they separate the cerebral from the cerebellar cavity.

Fig. 27.



HEAD OF THE CAT (POSTERIOR ASPECT).

1, Occipital bone; 2, zygomatic process of the temporal bone; 3, tympanic bulb; 4, condyle of the temporal bone; 5, malar bone; 6, orbital process of the malar; 7, ditto of frontal bone; 8, 8, palatine bones; 9, 9, maxillary bone; 10, premaxillary bone; 11, pterygoid bone; 12, sphenoid bone; 13, vomer.

Borders.—The *superior border* is notched, thick, and slightly dentated; it articulates with the occipital bone. The *inferior border*, slightly concave, and deeply dentated, offers an external bevel in its middle portion, and an internal bevel on its sides; it corresponds with the frontal bone. The *lateral borders* are very thin, and are cut, at the expense of the external plate, into a wide, sloping edge, which shows a groove destined to form the parieto-temporal canal. A very prominent angle separates each into two portions—an inferior, that articulates by suture with the squamous portion of the temporal bone; and a superior, curved inwards towards the centre of the cranial cavity. The latter portion of the lateral border is in contact with the anterior face of the petrous portion of the temporal bone, with which it concurs to form the lateral crest that descends to the parietal protuberance.

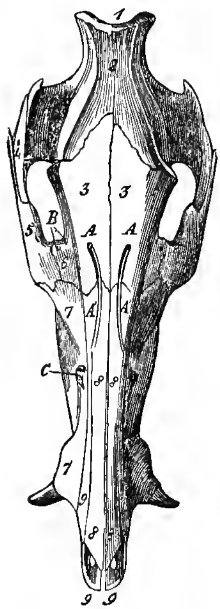
Structure.—This bone contains much compact tissue, the spongy substance existing only in its middle.

Development.—It is developed from two large lateral centres of ossification, to which is added a single centre to form the parietal protuberance. In early life the parietal ridges are absent.

DIFFERENTIAL CHARACTERS OF THE PARIETAL BONE IN OTHER ANIMALS.

A. **Ox.**—The parietal bone in the *Ox* does not occupy the anterior aspect of the head, but concurs with the occipital to form the base of the neck. It represents a very narrow osseous plate, elongated transversely, and curved at its two extremities, which descends into the temporal fossæ to rest upon the sphenoid bone. There are no parietal ridges. The internal protuberance is only marked by a slight elevation of the internal plate; for the most part it belongs to the occipital hone. The parietal bone of the Ox is developed from three centres of ossification, and the middle nucleus is even primarily divided into lateral halves; but these centres are consolidated with each other at an early period, as well as with the anterior portion of the occipital. It does not aid in the formation of the parieto-temporal canal, and is excavated internally by cavities which communicate with the frontal sinuses.

Fig. 28.



HEAD OF THE PIG (ANTERIOR FACE).

1, Summit of occipital tuberosity. 2, parietal bone. 3, frontal bone: A, Supra-orbital foramen; A′, channel descending from it. 4, zygomatic process. 5, malar bone. 6, lachrymal bone: B, Lachrymal canals. 7, supermaxillary bone: C, Inferior orifice of the supermaxillo-dental canal. 8, nasal bone. 9, premaxillary bone.

B. **Sheep, Goat.**—The parietal bone of the *Sheep* and *Goat* is relatively much larger than that of the Ox. It participates in the formation of the parieto-temporal canal, and has no sinuses.

C. **Camel.**—This bone occupies the anterior face of the cranium; but it is long, narrow, and deeply lodged between the squamous portion of the temporal bone and the frontal bone, to rest on the sphenoid. The parietal crests, thin and elevated, lie against each other for nearly their entire length, and are not prolonged to the frontal bone (Fig. 45). These crests do not exist at an early age.

D. **Pig.**—The parietal bone is very thick; it has two very marked crests, which do not meet at their upper part (Fig. 28).

E. **Dog, Cat.**—In the *Dog*, the parietal bone is distinguished by the great development of the temporal crests (Fig. 29).

In the *Cat* there are scarcely any parietal crests, and the internal protuberance is replaced by two great transverse bony plates, which separate the cavity of the cerebrum from that of the cerebellum.

F. **Rabbit.**—Almost quadrilateral, the parietal bone of the Rabbit has its temporal crests carried to near its lateral borders.

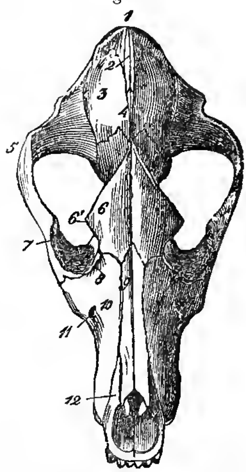
3. FRONTAL BONE (Fig. 26).

The *frontal* is a flat quadrilateral bone, the sides of which are bent in the middle at an acute angle, and are carried back, and a little inwards, to meet the wings of the sphenoid bone. It assists in forming the cranial roof and part of the face. It is bordered: above, by the parietal bone; below, by the nasal and lachrymal bones; and on each side, by the temporal bones. It offers for study an *external* and an *internal face*, and *four borders*.

Faces.—The *external face* is divided, by the double flexure of the bone, into three regions: a middle and two lateral. The first, nearly plane, is lozenge-shaped, is covered by the skin, and constitutes the base of the forehead. It gives rise on each side, at the point where it is inflected, to a long *process*, flattened above and below, which curves backward, forming the *orbital arch.* The superior or external face of this process is convex and slightly roughened; the internal face is smooth and concave, and forms part of the orbital fossa. Its posterior border, thick and concave, is continued, inwardly, with the corresponding parietal ridge, and outwardly with the superior border of the zygomatic process. It limits, in front, the temporal fossa. The anterior border, also concave, but thin, concurs in the formation of the orbital margin; the summit, thickened and denticulated, rests upon, and is united to, the zygomatic process of the temporal bone; the base is wide, and is traversed by an opening termed the *supra-orbital*, or *superciliary foramen*. The two lateral regions of the external face of the frontal bone are slightly excavated, and assist, for the greater portion of their extent, to form the orbits. They often show, near the base of the orbital arch, a small depression corresponding to the flexure described by the great oblique muscle of the eye in passing through its pulley.

The *internal face* of the frontal bone is concave, and divided into two unequal parts by a transverse ridge, corresponding to the anterior border of the cribriform plate of the ethmoid bone. The superior, the most extensive, is covered with digital impressions, and belongs to the cranial cavity. It exhibits: 1. On the median line, a slight furrow, or a crest which is continuous, above, with the median ridge of the parietal bone, and below, with the *crista-galli* process. 2. On the sides, and in the re-entering angle formed by the flexure of the bone, there is a narrow slit, or mortise, which receives the wing of the sphenoid bone. The inferior part is united, on the median line, to the perpendicular plate of the ethmoid. It assists in forming the bottom of the nasal cavities, and presents laterally two large openings which lead to the frontal sinuses—vast anfractuous spaces excavated between the two plates of the bone.

Fig. 29.



HEAD OF DOG (ANTERIOR FACE).

1, Occipital tuberosity; 2, median spur of the occipital bone; 3, parietal bone; 4, origin of the parietal crests; 5, zygomatic process of the temporal bone; 6, frontal bone; 6′, orbital process; 7, malar bone; 8, lachrymal bone; 9, nasal bone; 10, supermaxilla; 11, inferior orifice of the supermaxillo-dental canal; 12, premaxillary bone.

Borders.—The *superior border* is denticulated and cut obliquely in its middle portion, at the expense of the internal plate, and on the lateral parts at the expense of the external table; it is in contact with the parietal and squamous portion of the temporal bone. The *inferior*, prolonged to a point in the middle, is in apposition with the nasal bones through the medium of a wide external bevel; laterally, it is very thin, faintly serrated, and articulates with the lachrymal bone. The *lateral borders*, thin and irregular, present two notches: one, the superior (*incisura sphenoidalis*), is wide and deep, and occupied by the wing of the sphenoid bone; the other, inferior, is very narrow, and, uniting with a similar notch in the sphenoid bone, forms the *orbital foramen*, which opens into the cranium, very near, but external to, the ethmoid fossa. Each of these borders, also, is adapted, for a limited extent, to the corresponding palatine bone.

Structure.—The two compact plates of the frontal bone are separated by spongy texture towards the middle and in the upper part; they separate below to form the frontal sinuses. Laterally, they are very thin and consolidated with each other.

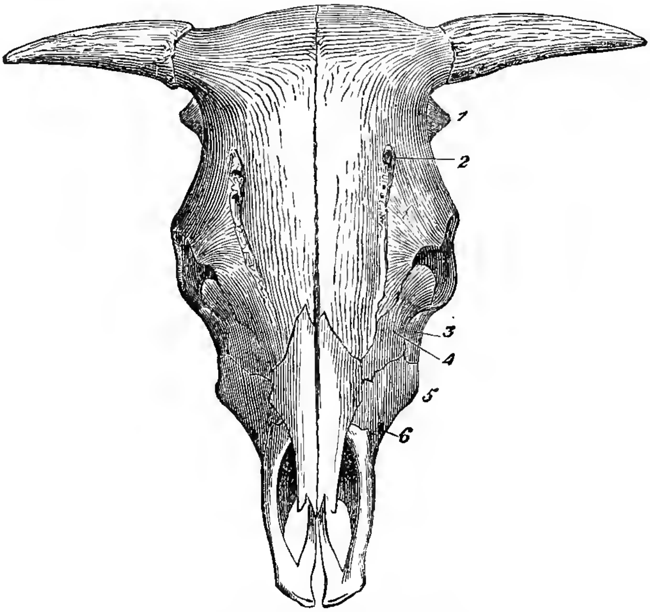
Development.—The frontal bone is developed from two lateral centres of ossification, which only coalesce at a late period. In youth the cranial portion of the bone forms, in front of the head, a large rounded protuberance standing beyond the facial portion. This prominence disappears when the frontal sinuses begin to be developed. These cavities do not exist at an early period of fœtal life; but commence to form about the fourth month of conception, by a process of resorption, which removes the spongy substance interposed between the two compact tables of bone, and may even cause the destruction of the internal table. The sinuses enlarge with age, and remain during life separated from one another by a vertical septum.

Differential Characters in the Frontal Bone of other Animals.

A. Ox, Sheep, Goat.—In Ruminants, the frontal bone does not come in contact with the temporal or palatine bones (Figs. 30, 31, 32).

In the *Ox*, this bone is extremely developed, occupying alone nearly one-half of the anterior surface of the head. It is particularly distinguished by: 1. Its great thickness. 2. The

Fig. 30.



OX'S HEAD (ANTERIOR FACE).

1, Mastoid process; 2, superciliary, or supra-orbital foramen; 3, malar bone; 4, lachrymal bone; 5, maxillary spine; 6, inferior orifice of the supermaxillo-dental canal.

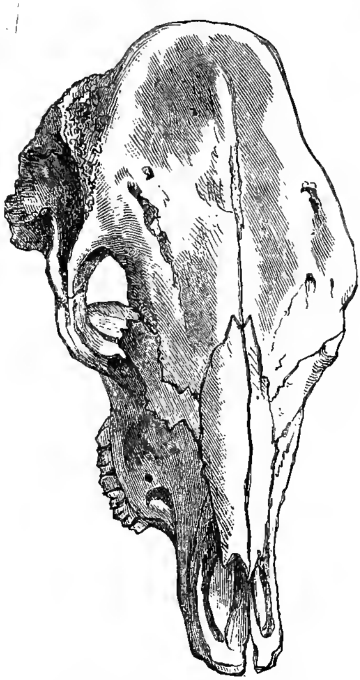
osseous conical cores which support the horns. These eminences, more or less long and curved, very rugged, perforated by foramina, and grooved by small vascular channels, are detached outwards from each side of the bone, near the summit of the head. The processes which form the orbital arches rest by their summits on the zygomatic bone. The supra-orbital foramen is transformed into a veritable and frequently multiple canal; its anterior orifice opens into a vasculo-nervous groove, which ascends towards the base of the horns, and descends to near the lower border of the bone. Between this groove and the base of the orbital arch is the frontal boss. The orbital foramen entirely belongs to this bone. The inferior border is deeply notched in its middle to receive the nasal bones; the frontal sinuses are prolonged into the horn-cores, the parietal bone, and even into the occipital bone.

The frontal bones of the Angus breed of cattle (*polled* cattle) have no horn cores. The ablation in the calf of the periosteum, followed by cauterization, at the point where appear the osseous prolongations which serve as bases for the horns, prevents the development of these appendages. Cornevin mentions that a farmer of Haute Marne has in this way mutilated the cattle bred on his farm for twenty-three years, and yet the mutilation has not become hereditary. Fig. 31, representing the head of an Ox so mutilated, shows that the removal of the periosteum in such animals has the effect of producing a considerable elongation and narrowing of the upper part of the frontal bone.

In the *Sheep* and *Goat*, the frontal bone is relatively less extensive and strong than in the Ox; it does not ascend to the summit of the head, and the frontal sinuses are not prolonged beyond its superior border (Fig. 32).

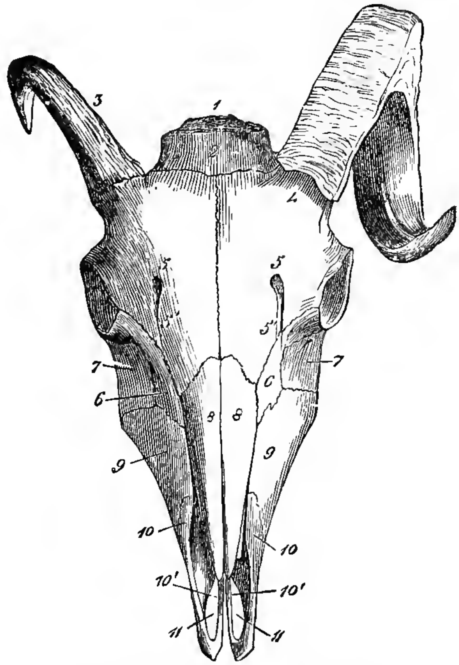
B. **Camel.**—The frontal bone of this animal much resembles that of Solipeds. The middle portion of its external face is triangular in shape, the base being wide, and the apex fixed in the deep notch formed on the inferior border of the parietal bone; it is slightly hollowed in the middle line, and convex on the lateral parts. The orbital arch rests on the

Fig. 31.



HEAD OF A HORNLESS OX.[1]

Fig. 32.



RAM'S HEAD (ANTERIOR FACE).

1, Occipital bone; 2, parietal bone; 3, core of right frontal bone; 4, the left core covered by its horn; 5, supra-orbital foramen; 5', channel descending from it; 6, lachrymal bone; 7, malar bone; 8, nasal bone; 9, supermaxillary bone; 10, premaxillary bone; 10', its internal process; 11, incisive opening.

zygomatic bone, as in the Ox (Fig. 37). The supra-orbital foramina are transformed into inflected canals, which open on the anterior face of the bone, near its middle.

On the circumference of the bone are several notches, some of which concur with the other bones, to form foramina (orbital, nasal); two are seen to the right and left of the line of union of the bone with the supra-nasal, and two others are in the orbital cavity. These openings are partially closed by the Wormian bones; they open into the upper compartments of the turbinated bones.

In the young Camel, the middle portion is deeply excavated; this excavation diminishes as the animal advances in age, and as the frontal sinuses enlarge.

C. **Pig.**—The frontal bone of the Pig is very thick and short, and does not join the temporal or zygomatic bones; the orbital arch is completed by a ligament. The supra-orbital foramen, disposed as in the Ox, abuts in a channel that descends on the nasal bones. The

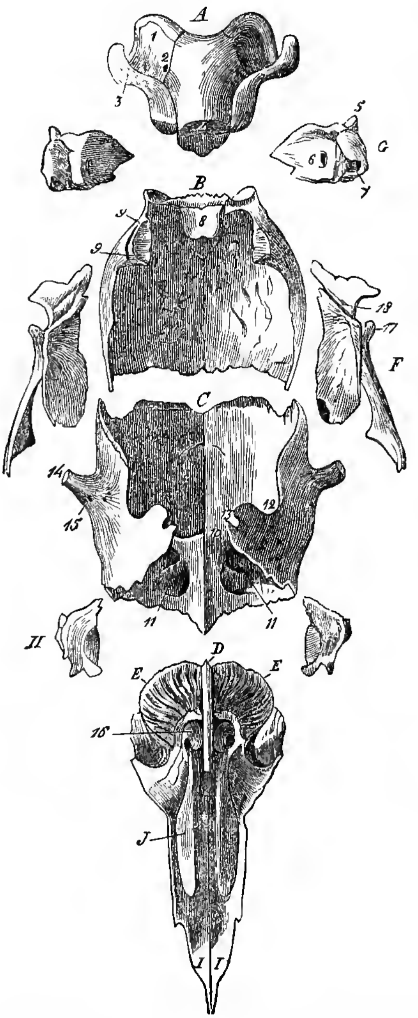
[1] In the Museum of the Lyons Veterinary School.

orbital foramen is formed by the frontal bone only. There is no mortise for the union of the frontal with the sphenoid bone; and the frontal sinuses are prolonged into the parietal. The frontal bone articulates with the superior maxillaries (Fig. 28).

D. **Carnivora.**—In the Carnivora, the external face of the frontal bone presents in its middle a more or less deep depression. The orbital arch is incomplete, and there is no supra-orbital foramen or mortise on the inner face. It unites with the superior maxillary bones (Fig. 29).

E. **Rabbit.**—In this animal the frontal bone is long and narrow, and the orbital process is thin, elevated, and directed upwards and backwards, but it does not reach the zygomatic bone, and is deeply notched at its base.

Fig. 33.



ANTERIOR BONES OF THE HEAD OF A FŒTUS (HORSE) AT BIRTH, DISARTICULATED, AND VIEWED FROM BEHIND.

A, Occipital bone: 1, condyle; 2, condyloid foramen; 3, styloid process; 4, summit of basilar process. B, Parietal bone: 8, parietal protuberance; 9, channel which concurs to form the parieto-temporal canal. C, Frontal bone: 10, transverse crests separating the cranial from the facial portion of the bone; 11, frontal sinuses; 12, notch on the lateral border occupied by the wing of the sphenoid bone; 13, notch for the formation of the orbital foramen; 14, summit of the orbital process; 15, supra-orbital foramen. D, Perpendicular lamina of the ethmoid bone. E, E, Lateral masses of the ethmoid bone: 16, the great ethmoid cell. F, Squamous portion of the temporal bone: 17, Supra-condyloid process; 18, channel for the formation of the parieto-temporal canal. G, Petrous portion of the temporal bone: 5, mastoid process; 6, internal auditory hiatus; 7, opening for the Eustachian tube into the tympanum. H, Lachrymal bone. I, Nasal bone. J, Superior turbinated bone.

4. Ethmoid Bone (Fig. 33).

The *ethmoid bone*, deeply situated in the limit between the cranium and the face, is enclosed between the frontal, the sphenoid, the vomer, the palatine, and the supermaxillary bones. It is composed of three portions—a *perpendicular plate*, and *two lateral masses*.

The Perpendicular Lamina of the Ethmoid Bone.—Situated in the mesian plane, and flattened on both sides, this bone presents *two faces*, a left and right, and *four borders*.

Faces.—The *faces*, covered by the pituitary membrane, present, posteriorly, small sinuous crests; elsewhere they are smooth. A very narrow interval, constituting the bottom of the nasal cavities, separates them from the lateral masses.

Borders.—The *superior border* looks towards the centre of the cranial cavity, and constitutes what is called the *ethmoidal ridge*, or *crista-galli process*. It is free, concave, and sharp, prolonged in front and above by the median crest of the frontal bone, and confounded behind with the middle portion of the inferior sphenoid. The *inferior border* is continuous with the cartilaginous plate which separates the nasal cavities. When this plate becomes ossified, which is not unfrequent, it is impossible to discover the point where it begins or the ethmoid bone terminates. The middle septum of the nose has been considered, and justly, as a prolongation of the perpendicular plate (or *lamina*) of this bone. The *anterior border* is consolidated with the vertical septum which separates the frontal sinuses. The *posterior border* is joined above to the median plate which divides the sphenoidal sinuses into two compartments. Below, it is fixed in the groove of the vomer, and soon becomes confounded with that bone, which is itself consolidated with the inferior sphenoid.

Lateral Masses of the Ethmoid Bone.—These are two large pyriform tuberosities placed on each side of the perpendicular lamina, and offering for study a *middle portion*, a *base*, and a *summit*. Each of these is formed by an assemblage of numerous, extremely thin, osseous plates, curved into small and very fragile convolutions. These, elongated from above to below, become longer as they are more anterior; they are attached by their superior extremities to the transverse plate which separates the cranium from the nasal cavities, and by one of their borders to a thin leaf of bone which envelops the lateral masses outwardly. They have received the name of the *ethmoidal volutes* (or *cells*).

Middle portion.—This should be studied externally and internally

The *external surface* of each ethmoidal mass is divided into two sections: an internal, making part of the nasal cavities; the other, external, concurs in forming the walls of the frontal and maxillary sinuses. The first, the least extensive, is almost plane; parallel to the perpendicular lamina, it is isolated from it by the narrow space which forms the bottom of the nasal cavities; it presents several openings which separate the most superficial cells, and join the internal canals to be hereafter noticed. The second, very extensive and convex, looks outwards in front and behind, and is covered by an osseous plate traced with shallow furrows, which correspond internally with the small crests to which the cells are attached. This lamella is prolonged, inferiorly, a little beneath the inferior extremity of these latter, and turns outwards to articulate with the palate and superior maxillary bones; superiorly, it coalesces with the sphenoid and the orbital portion of the frontal bone.

Internally, the lateral masses are hollowed from above to below by extremely diverging canals, which open inferiorly into the nasal cavities, and separate the cells from one another. The latter are so incurvated that the internal cells communicate with each other. There are some, however, which are completely closed; the anterior, or great cell, is frequently so.[1]

Base.—The *base* of each lateral mass looks upwards, and is formed by the transverse septum between the cranium and the nasal cavities. This septum is perforated by openings which give passage to the ethmoidal nerves; it is named the *cribriform plate* of the ethmoid bone. It is concave on the superior surface, which constitutes the *ethmoidal fossa*, and convex on the opposite face, where attachment is given to the superior extremities of the cells. It is consolidated internally with the perpendicular plate; the other points of its circumference are attached to the sphenoid bone, and to the transverse ridge on the internal face of the frontal bone.

[1] It is not rare to find it opening into the superior maxillary sinus.

Summit.—The *summit* of each lateral mass is formed by the inferior extremity of the ethmoidal cells, which is directed downwards, towards the nasal cavities. One, more voluminous than the others, is carried much lower, and terminates by a rounded protuberance. It corresponds to the middle cornu (*concha media*) of Man.

Structure of the ethmoid bone.—Very little spongy tissue enters into the composition of this bone, and this is only found near the anterior border of the perpendicular plate.

Development.—The ethmoid bone is late in attaining its development, and the adjoining bones are nearly completely ossified when it is yet entirely cartilaginous. The bony transformation commences in it at the inferior extremity of the cells, and advances progressively from below upwards. The perpendicular plate is only ossified in part when the cells have passed through the first half of the process; at the same time it coalesces with the inferior sphenoid. The cribriform plate is the last to become ossified, this transformation having scarcely been achieved when the animal is six or eight months old.

DIFFERENTIAL CHARACTERS IN THE ETHMOID BONE OF OTHER ANIMALS.

A. **Ox, Sheep, Goat.**—In Ruminants, the great ethmoidal cell is enormously developed, and looks like a third turbinated bone prolonged beyond the usual two; it has been named the *olfactory antrum.* The bone is closely imprisoned between the adjacent bones, in consequence of the slight development of the sinuses around it. This character otherwise belongs to all the domesticated animals, except Solipeds (Fig. 36).

B. **Camel.**—The crista-galli process is very thick, and the ethmoidal fossæ are narrow and deep.

C. **Pig.**—The superior turbinated bone is very long, and the papyraceous plate appears in the orbital cavity.

D. **Dog, Cat.**—The ethmoidal fossa is very deep, and the cells very developed and diverticulated. The perpendicular lamina is at a late period consolidated with the sphenoid bone.

5. SPHENOID BONE (Fig. 34).

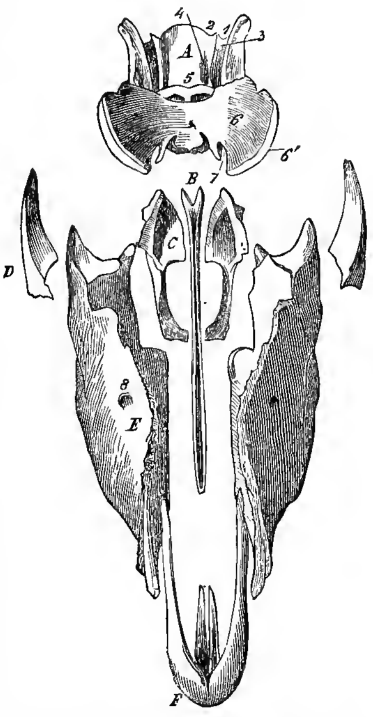
The *sphenoid* bone is situated behind the cranium, between the occipital, ethmoidal, palatine, vomer, pterygoid, frontal, and temporal bones. It is formed by the union of two pieces, which have been sometimes described as distinct bones—the *anterior* or *inferior sphenoid*, and the *posterior* or *superior sphenoid.* It is now supposed, in the description, that this union has been completed.

It is a bone flattened before and behind, curved from one side to the other, thick in its middle part, named the *body*, and thin on the sides, which, in their inferior half, are prolonged in the form of *alæ*, or *wings*. It has *two surfaces* and *four borders*.

Surfaces.—The *external surface* is convex, and presents: 1. On the median line, the external surface of the body, rounded from one side to the other, is continued with that of the basilar process, and has marked muscular imprints superiorly. 2. On the sides and from within outwards: (*a*) the *Vidian* (or *pterygoid*) *fissure*, directed from above downwards, and continued by the *Vidian canal*, a very small foramen which opens into the orbital hiatus; (*b*) the *sub-sphenoidal*, or *pterygoid process*, a long eminence, flattened on both sides, inclining downwards, articulating with the palatine and pterygoid bones, and traversed at its base by the Vidian canal; (*c*) a little behind and above this eminence, the superior orifice of the *sub-sphenoidal* (or *pterygoid*) *foramen*—a large canal which bifurcates inferiorly; (*d*) more in front, the *orbital hiatus*, a kind of vestibule into which open, in common, the principal branch of the subsphenoidal canal, the three supra-sphenoidal canals, the Vidian and optic canals, and the orbital opening: this hiatus is surmounted by a thin and sharp bony plate, above which opens the smallest branch of the subsphenoidal foramen; (*e*) altogether without the hiatus is remarked a smooth surface belonging to the wing of the sphenoid, and which concurs to form the orbital cavity.

The *internal face* is concave from side to side. It shows: 1. On the median line, and from before to behind, a small projection united to the *crista-galli;* the *optic fossa,* elongated transversely in the form of a shuttle, and presenting at the bottom, and on each side, the superior orifice of the optic foramen, a cylindrical canal directed obliquely downwards, forwards, and outwards, to reach the orbital hiatus; the *supra-sphenoidal* or *pituitary fossa,* also named the *sella Turcica,* a slight depression, limited behind by a scarcely noticeable transverse projection separating it from the superior channel of the basilar process. 2. On the sides, and in front, the internal surface of the wings, depressed by very superficial digital impressions; more behind and outwards, a fossa, elongated from before to behind, which lodges the mastoid lobule of the brain; between this fossa and the sella Turcica, two vertical fissures—an internal, named the *cavernous sinus,* and an external, wider and deeper, for the passage of a large nervous branch. These two fissures open below, near the junction of the three supra-sphenoidal canals. Two of these, which are very wide, are placed one before the other, and separated only by a slight partition. The superior of these constitutes the *great sphenoidal fissure* (*foramen lacerum orbitale*); the other, the lower, is the *foramen rotundum,* and opens into the orbital hiatus. The third, very small (*foramen patheticum*), is situated outside the great anterior canal, opens above the optic foramen, within the bony mass surmounting the hiatus, and sometimes on the free margin of this lamina.

Fig. 34.



POSTERIOR BONES OF THE HEAD OF A FŒTUS (HORSE) AT BIRTH, DISARTICULATED AND VIEWED IN FRONT.

A, Sphenoid bone: 1, maxillary notch; 2, carotid notch; 3, groove for the passage of the maxillary nerve; 4, cavernous sinus; 5, optic fossa; 6, great wing; 6′, unossified portion of the great wing; 7, notch for the formation of the orbital foramen. B, Vomer. C, Palatine bone. D, Malar bone. E, Supermaxilla: 8, inferior orifice of the maxillo-dental canal. F, Premaxillary bone.

Borders.—The *superior* is a little concave, and shows, in its middle, the superior extremity of the body, mammillated and articulated with the summit of the basilar process; on each side, two notches which circumscribe below the occipito-spheno-temporal hiatus (*foramen lacerum basis cranii*). The internal notch is the narrowest, and from its affording a passage for the internal carotid artery, is called the *carotid notch;* it is continued on the external face of the bone by a smooth excavation to which Rigot has given the name of *carotid fossa.* The external is also prolonged on the exterior surface of the sphenoid, by a short and wide fissure; it lodges the inferior maxillary nerve. Outside this is another very narrow notch, intended for the passage of the middle meningeal artery. The fibro-cartilaginous substance that partly fills the occipito-spheno-temporal hiatus, transforms these notches into foramina, the first of which is named the *carotid canal*; the second, the *foramen ovale*; and the third, the *foramen spinosum.* The *inferior border*, also concave, is likewise divided into three portions, a middle and two lateral. The first is thick, and formed by the inferior extremity of the body; it is excavated by two large cavities belonging to the sphenoidal sinus. These cavities are separated from one another by a vertical osseous plate, often perforated, which, at an early period, is fused with the perpendicular lamina of the ethmoid bone. The very thin lateral portions form part of the circumference of the wings; they are notched near their union with the middle piece to assist in the formation of the orbital foramen. The *two lateral borders* are thin and convex in their anterior half, as is also the contour of the wings, which are mortised in the frontal bone. For the remainder of their extent they are thick, denticulated, and bevelled at the expense of the external plate, to articulate with the squamous portion of the temporal bone.

Structure.—This bone is compact on its sides, and spongy in its middle part; inferiorly, it is excavated by the sphenoidal sinuses.

Development.—It is developed from two principal nuclei of ossification; a superior forms the subsphenoidal process and the canal of the same name, the Vidian fissure, pituitary fossa, fissures of the internal face, and the most posterior of the great supra-sphenoidal canals; the other, the inferior, forms that portion of the body hollowed by the sinuses, the lateral alæ,[1] and the optic fossa and canals. In meeting each other, these centres form the Vidian canal and the two anterior supra-sphenoidal canals. They are not consolidated with each other until a very late period; for which reason they are sometimes described as two distinct bones. M. Tabourin has even proposed to attach the description of the inferior sphenoid to that of the ethmoid, because it is united with this bone a long time before it is joined to the superior portion.[2]

Differential Characters in the Sphenoid Bone of other Animals.

A. **Ox.**—In the *Ox*, the subsphenoidal or pterygoid processes are large and thin The subsphenoidal canal is absent. The sella Turcica is deep, and the bony projection separating it from the basilar process is very high. The three supra-sphenoidal canals are converted into a single, but wide one. There are no notches in the superior border, for the passage of the internal carotid and spheno-spinous arteries. The oval foramen is entirely confined to this bone.

B. **Sheep.**—In the *Sheep*, the osseous prominence that limits the pituitary fossa posteriorly forms a lamina curving forwards, and prolonged at its extremities into two points, which constitute the *posterior clinoid processes.*

C. **Camel.**—The sphenoid is longer and thicker than in the Ox. The subsphenoidal or pterygoid processes are narrow and very thick. The oval foramen is relatively small. The optic canals are covered at their internal opening by a bony plate. The optic fossa is nearly on a level with the pituitary fossa.

D. **Pig.**—The sphenoid of the Pig is very short, but the subsphenoidal processes are extraordinarily developed, and flattened before and behind. There is no subsphenoidal canal, and the sella Turcica is deep, and limited behind by a very salient crest. A single canal

[1] These wings are not analogous to those portions of the sphenoid bone in Man bearing the same name. They are the processes of *Ingrassias* enormously developed.

[2] Tabourin, *Journal de Méd. Vétérinaire*, p. 229. Published at Lyons, 1845.

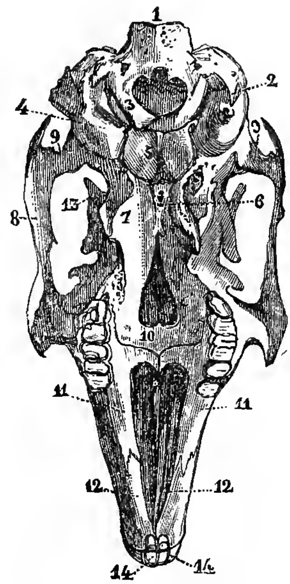
replaces the foramen rotundum and the great sphenoidal fissure, as in the Ox. The wings, slightly salient, are articulated by suture with the frontal bone.

E. Dog, Cat.—The superior sphenoid of the *Dog* is very short, and bears, laterally, two wide wings which ascend to the temporal fossa; they correspond to those of the sphenoid bone in Man. The inferior sphenoid is, on the contrary, very narrow, and its lateral prolongations, or processes of Ingrassias, are reduced to very small proportions. The subsphenoidal or pterygoid process is very short, and the canal is single, and communicates with the foramen rotundum. The pituitary fossa is shallow, limited behind and before by the *posterior clinoid* and *anterior clinoid processes*, so named because of their being compared to the four posts of an ancient bed. The supra-sphenoidal canals are only two in number: one represents the great sphenoidal fissure, the other the round foramen. The carotid notch, joining a similar one in the temporal bone, forms an opening which may be designated the *carotid foramen*, because it gives passage to an extremely remarkable loop the internal carotid artery describes after passing through the carotid canal. The oval foramen is the same as in the Ox.

In the *Cat* there is the same disposition, with the exception of no sphenoidal canal or carotid notch being present.

F. Rabbit.—The body of the sphenoid is short, triangular, thick at its upper border, pierced in the middle by an orifice which opens into the pituitary fossa. The wings are very developed; the subsphenoidal processes, bifid, are closely embraced by the pterygoids and palatine bones; and the optic fossa is replaced by a large foramen, which communicates at the same time with the two orbital fossæ.

Fig. 35.



HEAD OF THE RABBIT (POSTERIOR FACE).

1, Occipital tuberosity; 2, styloid process of the occipital bone; 3, condyle of ditto; 4, tympanic bulb; 5, basilar process of the occipital bone; 6, body of the sphenoid; 7, pterygoid bone; 8, zygomatic bone; 9, 9, condyles of the temporal bone; 10, palatine bone; 11, 11, superior maxillary bone; 12, 12, premaxilla; 13, orbital process of the frontal bone; 14, 14, superior double incisors.

6. Temporal Bone (Figs. 26, 33).

The *temporal bones* enclose the cranial cavity laterally, and articulate with the occipital, parietal, frontal, sphenoidal, and malar bones; also with the inferior maxilla and the hyoid bone. Each is divided into two pieces, which are never consolidated in the horse; one forms the *squamous portion of the temporal bone*; the other, the *petrous portion*. They will be described separately.

Squamous portion.—This is flattened on both sides, oval, and slightly incurvated like a shell, a shape to which it owes its name. It offers for study an *external* and an *internal face*, and a *circumference*.

Faces.—The *external face* is convex, and marked by some muscular imprints, vascular fissures, and openings which penetrate the parieto-temporal canal. It forms part of the temporal fossa, and gives origin near its middle to the *zygomatic process*—a long eminence which at first runs outwards, and soon curves forwards and downwards to terminate in a thin summit. The *base* of this eminence forms, in front, a concave surface belonging to the temporal fossa; behind, it offers the articular surface which corresponds with the maxillary bone. The latter is composed of: 1. A *condyle* transversely elongated, convex above and below, and slightly concave from side to side. 2. A *glenoid cavity*, limited below by the condyle, above by a mammiliform eminence, the *supra-condyloid* (or *anterior mastoid*) *process*,[1]

[1] In Man this is represented by the inferior or vertical ramus of the upper root of the zygomatic process.

against which rests the maxillary condyle when this bone is drawn backwards; it is immediately above this eminence that the inferior orifice of the parieto-temporal canal (*mastoid foramen*) opens. The *external face* of the zygomatic process is smooth and convex; the *internal*, concave, is also smooth, and bordered outwards by the temporal fossa. Its *anterior border* is sharp and convex; the *posterior*, very short, is thick and roughened. Its *summit* is flattened from before to behind, and marked by notches on its two faces; it somewhat resembles a wedge, fixed as it is between the orbital process of the frontal bone and the zygoma; it comes in contact with the maxillary bone, and by a small portion of its anterior face, which is deprived of notches, it concurs in circumscribing the orbital cavity. In the domesticated animals, as in Man, the zygomatic process appears to arise from the surface of the bone by two roots—one, the *inferior* or *transverse*, is represented by the condyle; the other, the *superior*, forms a sharp crest which is continuous with the anterior border of the process, and above, joins the lateral crest of the occipital protuberance.

The *internal* or *cerebral* face of the squamous portion is divided into two parts by an almost vertical channel, which terminates above the supra-condyloid process, and which, meeting a similar furrow on the parietal bone, forms the *parieto-temporal canal.* The superior portion is of small extent, and of a triangular form; it articulates by a simple harmonia suture with the external face of the petrous portion. The inferior part, the widest, present in its middle some cerebral impressions. For the remainder of its extent or circumference, it is cut into a wide, dentated, and lamellar bevel, which brings it in contact with the surrounding bones.

Circumference.—This may be divided into *two borders:* one, *anterior*, is convex and united with the parietal and frontal bones; the other, *posterior*, articulates with the sphenoid in its inferior moiety, and is provided, above the level of the supra-condyloid process, with a deep notch which receives the external auditory canal. Superiorly, the two borders unite at the summit in a thin point, which rests on the occipital bone.

Structure.—The squamous portion of the temporal bone is formed of two very thin compact plates, which have but little spongy tissue between them; the latter, however, is very abundant in the body of the zygomatic process.

Development.—It is developed from a single nucleus of ossification.

Petrous Portion.—This is one of the most interesting parts of the skeleton for study, in consequence of its containing two systems of cavities which enclose the essential organs of hearing. One of these systems is named the *cavity of the tympanum* or *middle ear;* the other forms the *internal ear.* These cavities will be studied when we come to speak of the auditory apparatus. In the mean time, only the external surface, and the structure and development of this portion of the temporal bone, will be noticed.

It is wedged between the antero-lateral border of the occipital bone, the lateral border of the parietal, and the superior part of the internal face of the temporal shell. It represents a quadrangular pyramid, the base of which is turned downwards and a little backwards. It will be studied successively in *four faces*, a *summit*, and *base.*

Faces.—The *anterior face* is united by harmonia suture to the parietal bone. The *posterior face* articulates in the same manner with the occipital bone. The *external face* lies against the squamous portion of the bone. The *internal face*, slightly concave and marked by very superficial digital impressions, forms a part of the lateral wall of the cerebellar cavity. It presents the *canal* or *internal auditory hiatus* (*meatus auditorius internus*), a small fossa, the bottom of which is pierced by several foramina for the transmission of nerves; the largest of these is the internal orifice of the *aquæductus Fallopii*—a flexuous canal which passes through the bone and opens at the external surface of its base; the other foramina penetrate the cavities of the internal ear.

These faces are separated from each other by so many *borders* or *plane angles*, two of which more particularly merit attention; one of these isolates the external from the posterior face, and the other separates the anterior from the internal face. The *first* is thick and rugged, and constitutes the *mastoid crest;* it is continuous above with the lateral ridge of the occipital bone, after being united to the superior root of the zygomatic process, and terminates, near the base of the bone, by a tuberosity for muscular insertion, to which has been given the name of (*posterior*) *mastoid process*. This border is traversed by a slit, the *mastoid fissure*,[1] which passes under the squamous portion and enters the parieto-temporal canal. The *second* is thin, and, with the superior part of the lateral border of the parietal bone, forms the crest which establishes the line of demarcation between the cerebral and cerebellar cavities of the cranium; it gives attachment to the tentorium cerebelli.

Summit.—This is slightly denticulated, and articulates with the occipital bone.

Base.—This is very irregular, and offers: outwardly, the *external auditory canal* which penetrates the middle ear, and the external orifice of which has been named in veterinary anatomy the *external auditory hiatus;* inwardly, a sharp crest which circumscribes the external contour of the foramen lacerum basis cranii; above, and under the mastoid process, the *stylo-mastoid* or *pre-mastoid foramen*, the external orifice of the aqueduct of Fallopius; below, the *subuliform* (or *styloid*) *process* for the attachment of the tensor palati muscle and the Eustachian tube: this is a long, thin, and pointed process presenting, at its base and within, a canal (*styloid foramen*) which enters the cavity of the tympanum, and which is incompletely partitioned by a small bony plate into two parallel portions; in the centre, the *hyoid prolongation* or *vaginal process*[2]—a little cylindrical eminence surrounded by a bony sheath, and the *mastoid protuberance* or *auditory bulla*—a slightly salient, smooth, and round eminence hollowed internally by numerous cells, which form part of the middle ear.

The several small and very remarkable canals which pass through the petrous portion of the temporal bone, will be noticed when the nervous and arterial branches they lodge are described.

Development.—The petrous portion of the temporal bone is developed from two principal centres of ossification which are consolidated at birth, and which are often described as two distinct portions—the one as the *petrous* or *stony portion*, the other as the *mastoid portion*.

The faces, borders, summit, and inner side of the base of the bone are formed by the *petrous* part, which contains the cavities of the internal ear and furnishes the inner wall of the middle ear.

The *mastoid portion* constitutes almost entirely the base of the temporal pyramid; to it belong the external auditory canal, the mastoid process, the sheath of the hyoid prolongation, and the styloid process; it forms the external wall and circumference of the case of the tympanum.

[1] This is the analogue of the *mastoid canal* in Man.
[2] This process is prolonged by a cartilage that unites it to the *styloid bone*.

For the petrous portion of the temporal bone there are also two small complementary nuclei : one for the vaginal process—the base of which is united to the petrous portion, and another forming the ring of the tympanum.

Structure.—The petrous portion is the hardest mass of bone in the skeleton, and scarcely contains any spongy tissue, except at the centre of the mastoid process ; in the mastoid portion it may be said not to exist.

Differential Characters in the Temporal Bone of other Animals.

In the other domestic animals, the petrous portion of the temporal bone becomes consolidated with the squamous portion, and the summit of the zygomatic process only articulates with the malar bone.

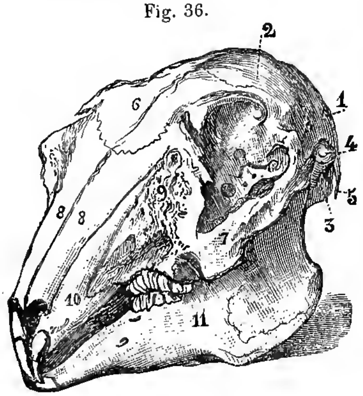
A. **Ox, Sheep, Goat.**—The condyle of the zygomatic process is very wide and convex in every sense. The parieto-temporal canal is very large, and entirely excavated in the temporal bone; its superior or internal extremity opens above the petrous portion in an excavation which represents the lateral cavity of the parietal protuberance in the Horse ; at its inferior extremity it always shows several orifices.

The mastoid process is very salient, and belongs to the squamous portion. The mastoid crest is confounded with the upper root of the zygomatic process ; inferiorly, it surpasses the mastoid process, and is prolonged to the mastoid protuberance. The latter is very voluminous. The subuliform process is larger and stronger than in the Horse ; there is no mastoid fissure.

In the *Sheep* and *Goat*, the mastoid process is scarcely distinct from the crest ; and the mastoid portion of the bone is only at a late period consolidated with the petrous portion.

B. **Camel.**—The squamous portion of the temporal is wider than that of the Horse; it is excavated in the upper part of its external surface. The zygomatic process has a large and thin base; its articular surface is nearly level from before to behind, and is concave from one side to the other; the supra-condyloid process is very developed (Fig. 45). The petrous portion is thin, and closely confined between the occipital and squamous bones. The mastoid crest and process are not markedly developed. The hyoid prolongation is placed at the bottom of a great bony sheath.

Fig. 36.



HEAD OF THE RABBIT (ANTERO-LATERAL FACE).

1, Occipital bone; 2, parietal; 3, tympanic bulb; 4, auditory canal; 8, 8, nasal bones; 9, supermaxilla; 10, premaxilla; 11, inferior maxilla.

C. **Pig.**—The articular surface of this bone resembles that of Rodents; it is not limited posteriorly by a subcondyloid eminence, and, in addition, offers a wider transverse surface. The zygomatic process articulates with the jugal bone by the whole extent of its posterior border. A crest leading from the external auditory hiatus to the mastoid protuberance replaces the mastoid process. The mastoid crest is, as in the Ox, confounded with the superior root of the zygomatic process.

D. **Carnivora.**—In the Carnivora, the articular surface of the zygomatic process merely forms a glenoid cavity, into which the condyle of the maxillary bone exactly fits. The temporal bone in these animals is also distinguished by the width of the external auditory canal, the absence of a hyoid prolongation, the small development of the mastoid and styloid processes, the enormous volume of the mastoid protuberance, and the presence of two particular canals which cannot be traced in the other animals. One of them—the *carotid canal*—traverses the mastoid portion, and joins, superiorly, the venous canal which passes between the basilar process and the temporal bone; by its inferior extremity it joins the carotid foramen, which itself penetrates the cranium, a little beyond the venous canal just mentioned. The other conduit is pierced in the petrous portion immediately above the carotid canal; it affords a passage to the fifth pair of cranial nerves.

E. **Rabbit.**—The squamous portion is circular, and has a short process flattened from before to behind at its base, and from side to side at its extremity. The articular surface is concave transversely, and elongated from before to behind. The petrous portion has a considerable tympanic bulb applied closely to the auditory canal, which is large and oblique behind. The mastoid process is a simple crest situated above the auditory canal; the hyoid prolongation is absent.

Bones of the Face.

The *face* is much more extensive than the cranium in the majority of the domesticated animals, and is composed of *two jaws*—a bony apparatus that serves as a support to the passive organs of mastication—the teeth. The *superior* or *anterior jaw*, traversed in its entire length by the nasal cavities, is formed by nineteen flat bones, only one of which, the *vomer*, is a single bone. The pairs are: the *superior* and *intermaxillaries* (or *premaxillaries*), the *palate*, *pterygoid*, *malar*, *lachrymal*, *nasal*, and *superior* and *inferior turbinated bones*. Of these only four—the maxillaries—are intended for the implantation of the teeth; the others form the union between the cranium and the superior maxilla, or concur in the formation of the nasal cavities. The *lower jaw* has for its base a single bone—the *inferior maxilla*, or *maxillary bone*.

1. Superior Maxillary Bone (Fig. 26).

This bone, also named the *supermaxillary bone*, the most extensive in the upper jaw, is situated on the side of the face, and is bordered above by the frontal, palate, zygomatic, and lachrymal bones; below, by the premaxillary bones; in front, by the nasal bone; behind and within, by that of the opposite side. It is elongated vertically, is irregularly triangular, and exhibits *two faces*, *two borders*, and *two extremities*.

Faces.—The *external face*, which is more convex in the young than the old animal, presents: 1. On the level of the fourth and fifth molar teeth, a vertically elongated ridge which is continued above with the inferior border of the zygomatic bone; this is the *maxillary spine*. 2. The inferior orifice of the *maxillo-dental canal*, or *infra-orbital foramen*.

The *internal face* concurs in forming the external parietes of the nasal cavities. We observe, above and in front, a deep, wide, and diverticulated excavation, forming part of the maxillary sinus; above and behind, a surface roughened by fine lamellæ and denticulations to correspond with the palate bone, and traversed from above to below by a fissure which forms, in uniting with a similar fissure in the latter bone, the *palatine canal*. For the remainder of its extent it is unequally smooth, covered by the membrane of the nose, and divided into two surfaces by a slightly vertical and sinuous crest that affords attachment to the maxillary turbinated bone: the anterior surface, which responds to the middle meatus of the nasal fossa, shows the lower orifice of the *osseous lachrymal canal* continued by a fissure to the lower extremity of the bone; the posterior surface belongs to the inferior meatus. From this face is detached, near its inferior border, a wide and long vertical plate, which forms, in Man and short-faced animals, a simple process—the *palatine process*. This plate, uniting in the middle line with that on the opposite side, concurs in forming the greater portion of the palatine arch. It shows: an anterior slightly concave face, forming the floor of the nasal fossæ; a posterior face, buccal, furrowed by small fissures, perforated by fine openings, and traversed along its length by a somewhat wide groove—the *palatine fissure*, which commences above at the lower orifice of the palatine canal; a denticulated border which articulates with a similar border on the palatine process of the opposite side.

Borders.—The *anterior*, thin and convex, is divided into two parts: an inferior, which is mortised to receive the external border of the nasal bone and the external process of the premaxilla; and a superior, cut in a wide bevel, at the expense of the external plate, to respond to the lachrymal and zygomatic bones. The *external* border is very thick, and hollowed into six large quadrilateral cavities, named *alveoli*, in which are implanted the molar teeth. Above the last alveolus it forms a rugged eminence designated the *alveolar tuberosity*; below the first alveolus it becomes thin and sharp, and constitutes part of the interdental space (*diastema*) which separates the molar from the incisor teeth.

Extremities.—The *superior* is the thickest, and represents a smooth rounded protuberance, into the interior of which the maxillary sinus is prolonged. Above and within this eminence is a wide and deep excavation, in the formation of which the palate bones participate. This is the *maxillary hiatus*, situated directly opposite the orbital hiatus. At the bottom of this cavity is seen the nasal foramen, as well as the upper orifice of the infra-orbital and the palatine canals. The *nasal foramen* belongs to the palate bone, and enters the nasal cavity. The *infra-orbital canal* traverses the maxillary sinus in passing above the roots of the molar teeth, and terminates by two branches—one, short and wide, which opens on the external surface of the bone, on a level with the third molar; the other, very narrow, continues the course of the canal in the substance of the bone, and is prolonged by several small, very fine branches into the premaxillary bone. The *palatine canal*, channeled between the supermaxillary and the palate bone, extends from the maxillary hiatus to the palatine fissure.

The *inferior extremity* presents a cavity which forms the alveolus of the tusk, by uniting with a similar space in the premaxillary bone.

Structure and development.—This bone is developed from a single nucleus, and is the more spongy—particularly towards the alveolar border and the superior extremity—as the animal is young.

Differential Characters in the Superior Maxillary Bone of the other Animals.

A. **Ox, Sheep, Goat.**—In the *Ox*, *Sheep*, and *Goat*, the maxillary spine does not directly join the zygomatic crest; a curved line, with concavity posterior, effects the union between these two parts. The inferior orifice of the infra-orbital foramen is pierced above the first molar tooth. There is no fissure for the formation of the palatine canal. The cavity of the sinus is more spacious than in the Horse, and is prolonged (in the Ox only) between the two laminæ of the palatine roof. There is no alveolus for the tusk.

B. **Camel.**—Not so long or wide as in the Horse and Ox, the supermaxilla of the Camel is deeply excavated above the forehead and the orbit. The maxillary spine is replaced by a round and smooth prominence, which disappears at the inferior opening of the superior dental canal, pierced above the interval separating the second from the third molar. The posterior face of the palatine process is narrow, has no palatine fissure, but shows the orifice of the palatine canal.

C. **Pig.**—In the *Pig*, the external surface of this bone is hollowed in its middle, and presents in front a voluminous relief formed by the alveolus of the canine tooth. The cavity is entirely formed in the supermaxilla. There is no alveolar tuberosity, and the interdental space is very short, while the cavity for the sinus is little developed. The lower orifice of the palatine canal is even pierced in the substance of the supermaxilla.

D.—**Dog, Cat.**—In Carnivora, this bone is very short; its anterior border offers a long process analogous to the nasal spine of Man. It alone furnishes the alveolus of the tusk. The palatine canal, pierced entirely in the bone of that name, nevertheless opens, by its inferior extremity, at the junction of the supermaxilla with the palatine bone. The maxillary sinus is not very spacious, and there is no maxillary spine (Fig. 29).

E. **Rabbit.**—The superior maxilla in this animal is less extensive, proportionately, than that of the other animals. The external table is thin, and even cribriform. The malar tubercle is narrow and directed outwards. The palatine process is very narrow, and therefore only very slightly concurs in the formation of the arch of the palate; it does not extend to the summit of the internal process of the incisive bone (Fig. 36).

Fig. 37.

OX'S HEAD (POSTERIOR FACE).

A, Parietal bone: 1, occipital foramen; 2, occipital condyle; 3, styloid process of that bone; 4, condyloid foramina; 5, mastoid process; 6, mastoid protuberance; 7, subuliform (temporal) process; 8, hyoideal sheath; 9, stylo-mastoid foramen; 10, external auditory hiatus; 11, inferior orifice of the parieto-temporal canal; 12, temporal condyle; 13, posterior foramen lacerum; 14, oval foramen; 17, subsphenoidal process; 18, orbital hiatus; 19, optic foramen. B, Frontal bone: 20, supra-orbital foramen; 21, orbital foramen; 22, lachrymal protuberance. C, Malar bone: 23, pterygoid bone. D, Palatine bone: 24, nasal foramen; 25, inferior orifice of the palatine canal. E, Supermaxillary bone: 26, maxillary spine. G, Premaxillary bone: 27, its internal process; 28, external process; 29, incisive openings.

2. Premaxillary, Intermaxillary, or Incisive Bone (Figs. 26, 38).

This bone occupies the inferior extremity of the head, and is composed of a *thick prismatic portion*, lengthened superiorly by two long *processes*.

Thick portion or base.—This presents a solid mass with *three faces:* an *external* or *labial*, smooth and convex; an *internal*, denticulated for union with the opposite bone, and traversed from before to behind by an inflexed fissure, which forms, with an analogous one in the other premaxilla, the *incisive canal* or *foramen incisivum;* the third or *posterior*, also called the *buccal*, is slightly concave, and shows the continuation of the palatine groove, which terminates in the incisive foramen. These three faces are separated by as many borders: *two internal*, limiting the corresponding face before and behind; and *an external*, separating the labial from the buccal face. The latter only merits notice. It is very thick, and is divided into two parts: an inferior, which describes a curved line, concavity upwards, and is excavated by three alveoli for the reception of the incisor teeth; another, the superior, is straight, vertical, and somewhat sharp, and forms part of the dental interspace. It is limited above, near the base of the external process, by a cavity for the formation of the alveolus of the canine tooth.

Processes.—These are distinguished as *external* and *internal*. The first, the longest and strongest, is flattened on both sides; its external face is smooth, and continued with that of the thick portion of the bone; its internal face is covered by the mucous membrane of the nose; the anterior border is smooth and rounded; the posterior, denticulated to respond to the supermaxillary bone, is in contact with the external border of the base; its summit is thin, and is insinuated between the latter and the nasal bone. The *internal* (or *palatine*) *process*, the smallest, is flattened from before to behind, and forms a very thin tongue of bone, separated from the other portions by a narrow and very deep notch, named the *incisive opening* or *cleft*. Its inferior face constitutes a small portion of the floor of the nasal fossæ; the posterior, continuous with the same face of the principal mass of the bone, forms part of the palatine roof; its external border circumscribes, inwardly, the incisive opening; the internal is united by dentated suture with the opposite bone.

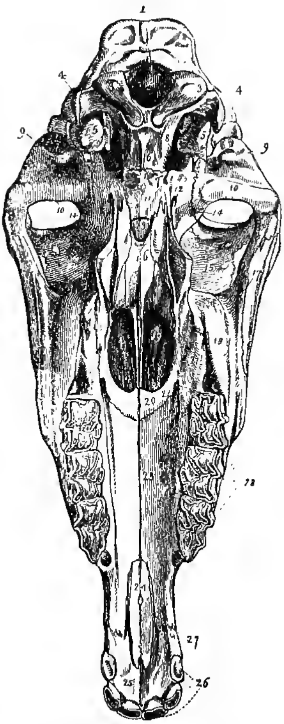
Structure and development.—It is a spongy bone, developed from a single nucleus.

Differential Characters in the Premaxillary Bone of other Animals.

A. **Ox, Sheep, Goat** (Fig. 37).—The inferior or principal portion of this bone is flattened before and behind, and deprived of alveoli in its external border; neither is there any incisive foramen. It is rarely consolidated with the adjacent bones, and is never, in the smaller Ruminants (*Sheep* and *Goat*), articulated with the nasal bone by the summit of the external process.

B. **Camel.**—By its form, the premaxillary bone much resembles that of the smaller Ruminants. Its base is not so wide, but it is thicker than in the Ox. This base is rugg d in its lower surface, and excavat d by an alveolar

Fig. 38.



POSTERIOR ASPECT OF HORSE'S SKULL.

1, Occipital tuberosity; 2, foramen magnum; 3, 3, occipital condyles; 4, 4, styloid processes; 5, 5, petrous bone; 6, basilar process; 7, pterygoid fissure of the sphenoid bone; 8, foramen lacerum; 9, 9, supracondyloid, or anterior mastoid process; 10, 10, articular eminence, or temporal condyle; 11, body of sphenoid bone; 12, pterygoid process; 13, ethmoid bone; 14, temporal bone and sphenoidal suture; 15, lachrymal bone; 16, vomer; 17, malar bone; 18, maxillary tuberosity; 19, posterior nares, or guttural opening of the nose; 20, palatine bone; 21, palatine styloid process; 22, palato-maxillary foramen; 23, palatine process of superior maxillary bone, with suture; 24, ditto of premaxillary bone; 25, premaxillary bone; 26, upper incisor teeth; 27, point of junction of the premaxillary with the supermaxillary bone; 28, upper molar teeth (young mouth).

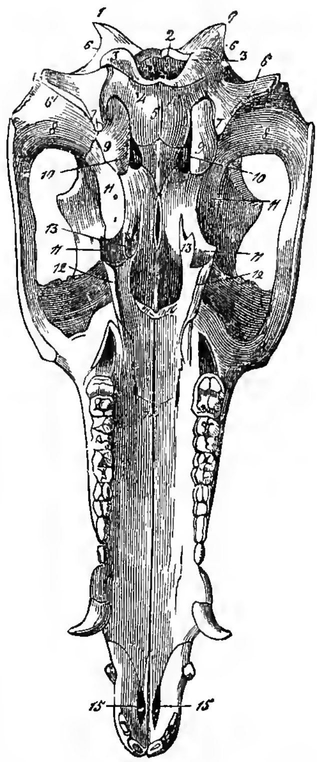
cavity. The incisive opening is very small, and the external process does not reach the nasal bone.

C. **Pig.**—In the *Pig*, the external process of the premaxillary bone is very long and wide at its base, and consolidated with the nasal bone for about the upper two-thirds of its length. There is no incisive foramen or cavity for the tusk. The incisive openings are oval.

D. **Dog, Cat.**—Of small size, the premaxilla of Carnivora has no incisive foramen or alveolar cavity for the canine tooth. The incisive openings are the same as in the Pig.

E. **Rabbit.**—Proportionately voluminous, the premaxilla of the *Rabbit* is remarkable for the great development of its ascending processes, which reach the frontal bone, and the width of the incisive slits, which are confounded above the internal processes. It carries two incisors, placed one before the other.

Fig. 39.



HEAD OF THE PIG (POSTERIOR FACE).

1, Occipital tuberosity; 2, occipital foramen; 3, occipital condyle; 4, condyloid foramen; 5, basilar process; 6, 6, mastoid crest; 7, styloid process of the occipital bone; 8, articular surface of the temporal bone; 9, mastoid protuberance; 10, foramen lacerum; 11, subsphenoidal process — external wing of pterygoid process; 12, palatine crest; 13, pterygoid bone (internal wing of the pterygoid process); 14, inferior orifice of the palatine canal; 15, 15, incisive openings.

3. Palatine Bones (Fig. 38).

The *palate* or *palatine bones* are situated between the supermaxillaries, at the margin of the guttural opening of the nasal cavities, and are articulated with the sphenoid, ethmoid, vomer, frontal, and pterygoid bones. Elongated from above to below, flattened laterally, and curved towards each other at their inferior extremity, which is flattened from before to behind, these bones, though irregular in shape, offer for study *two faces*, *two borders*, and *two extremities*.

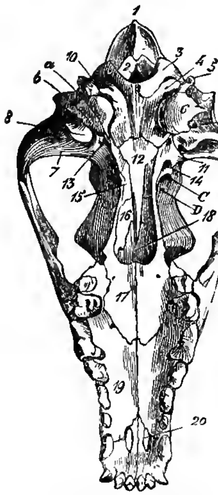
Faces.—The *external face* of the palate bone is divided into three fractions—a superior, or *orbital*, an inferior, or *palatine*, and a middle, or *articular*. The first is smooth and slightly excavated, and participates in the formation of the maxillary hiatus; it shows a small groove, the *staphyloid*, which reaches the palatine fraction in passing between the posterior border of the bone and the alveolar tuberosity. The second is not extensive, and looks backwards in consequence of the antero-posterior flattening which the bone presents at its inferior extremity; it forms part of the roof of the palate. The third presents a lamellar and denticulated surface which corresponds to a similar face on the supermaxillary bone, and is channeled from above to below by the internal groove of the palatine canal.

The *internal face*, smooth and concave, forms part of the external wall and the floor of the nasal fossa.

Borders.—The *anterior* is indented, near its superior third, by a deep notch, which is often converted into a foramen, the *nasal*. Below this notch the bone is thin and denticulated for union with the supermaxillary bone; above, its two plates separate widely from one another, giving rise to a very spacious cavity which forms part of the sphenoid sinus. The *posterior border* presents, above, a rugged crest called the *palatine*, flattened from side to side, bent outwards, and bordered at its base and inwards by a very narrow synarthrodial surface, which responds to the pterygoid bone. It is smooth and concave in its inferior half, and forms, with that of the opposite side, a parabolic arch (*palatine arch*) which circumscribes, below and at the side, the double guttural orifice of the nasal cavities.

Extremities.—The *superior*, flattened on both sides, is bevelled on the external side to articulate with the subsphenoidal process. The *inferior*, flattened from before to behind, is curved inwards and united by simple suture with that of the opposite bone.

Fig. 40.



DOG'S HEAD (POSTERIOR FACE).

1, Occipital tuberosity; 2, occipital foramen; 3, occipital condyle; 4, condyloid foramen; 5, styloid process of the occipital; 6, mastoid protuberance; 7, concave temporo-maxillary articular surface; 8, supra-condyloid eminence; 9, inferior orifice of the parieto-temporal canal; 10, posterior foramen lacerum; 11, ditto, anterior. On the opposite side at *a* is shown the orifice communicating with the Eustachian tube and the tympanum; at *b* the passage for the carotid loop. 12, Body of the sphenoid; 13, oval foramen; 14, inferior orifice of the subsphenoidal canal; 15, pterygoid bone; 16, nasal surface of the palate bone; 17, palatine surface of the same; 18, vomer; 19, supermaxillary bone; 20, incisive opening.

Structure and development.—This is a very compact bone, developed from a single centre of ossification.

Differential Characters in the Palatine Bone in other Animals.

The principal distinctive feature of this bone in the different domestic animals is due to the part it takes in forming the arch of the palate. In this respect there are very great differences in various species, but in none of them is this part so reduced as in Solipeds, in which the bone is scarcely equal to one-fifth of the palatine surface.

A. **Ox, Sheep, Goat.**—The palatine bone in these animals is very developed, and noticeable for the considerable extent of the palatine portion of its external surface. The palatine canal is entirely channeled out in its substance. The palatine crest, very thin and elevated, is formed altogether by the posterior border of the palate bone, the pterygoid, and the subsphenoidal process. There is no excavation for the sphenoidal sinuses; but, instead, all that part of the bone which enters into the roof of the palate is hollowed, but in the *Ox* only, by irregular cavities which communicate with the maxillary sinus of the same side. The nasal foramen is very wide.

B. **Camel.**—The staphyline fissure is wide and deep; the palatine crest is very developed, and has two rugged depressions at its base. The palatine canal is not included in the palate bone; it opens at the second molar.

C. **Pig.**—The palatine portion is less developed than in Ruminants, for it forms less than one-fourth of the palatine arch; on the other hand, the orbital portion is very limited. The palatine crest is replaced by a tuberosity, against which rests, outwardly, the subsphenoidal process, and inwardly the pterygoid bone. The union of these three parts constitutes, on the posterior surface of the head, a thick and very remarkable trifid projection or mamelon.

D. **Dog, Cat.**—It is in the Carnivora that the palatine bones are of greatest extent in their proper palatine portion, as they constitute nearly one-half of the palatine arch. They have no share in the formation of the sphenoidal sinuses, but furnish a small excavation to the maxillary sinuses.

E. **Rabbit.**—The palatine bones resemble those of the Horse, with regard to the part they play in forming the palatine arch. The palatine canal opens also between the palatine and superior maxillary bones, but the palatine crests are proportionately more developed than in Solipeds (Fig. 35).

4. Pterygoid Bone (Figs. 34, 38).[1]

A small and very short bone, elongated from above to below, flattened on both sides, and situated on the inner aspect of the subsphenoidal process, but external to the vomer.

Its *external face* is in contact with the palate and sphenoid bones; the *internal* is smooth, and covered by the pharyngeal mucous membrane. Its *superior extremity* is tapering, and concurs in forming the Vidian canal; the *inferior* is thickened into a small pointed process (the *hamular process*), the apex of which, directed backwards, offers outwardly a groove which serves as a pulley to the tendon of the tensor palati muscle.

This bone is composed entirely of compact tissue, and is developed from a single centre of ossification.

Differential Characters in the Pterygoid Bone of other Animals.

A. **Ox, Sheep, Goat.**—The pterygoid of the *Ox*, *Sheep*, and *Goat* is very wide, and closes an aperture left between the sphenoid and palatine bones.

B. **Camel.**—In the *Camel* the pterygoid is short, broad, and applied to the internal face of the subsphenoidal process and palatine crest. It does not concur in the formation of the Vidian canal. Its inferior extremity has a narrow and deep fissure.

C. **Pig.**—(See the description of the palatine bone.)

D. **Carnivora.**—This bone is very strong in Carnivora, and quadrilateral in shape.

5. Malar or Zygomatic Bone (Figs. 26, 34).

This bone, also designated the *jugal* bone, is elongated from above to below, flattened on both sides, and irregularly triangular in shape; it is situated on the side of the face, and articulates with the supermaxillary, lachrymal, and temporal bones. It is described as having *two faces*, *two borders*, a *base*, and a *summit*.

Faces.—The *external face* comprises two portions separated from each other by a semicircular ridge that extends from the summit to the middle of the anterior border of the bone, and concurs to form the outer margin of the orbit. The anterior portion, smooth and concave, belongs to the orbital cavity. The posterior, more extensive, is also smooth and slightly convex. The *internal face* is excavated in its central part, which corresponds to the maxillary sinus. On its margin it shows denticulations and lamellæ for articulation with the supermaxillary bone.

Borders.—The *anterior*, thin and denticulated, is joined to the lachrymal bone. The *posterior*, or *masseteric border*, is thicker, and constitutes a roughened crest, the *zygomatic ridge*, which is continued above with the posterior border of the process of the same name, and below with the maxillary spine.

Base and summit.—The *base*, very thin, is united to the supermaxillary bone. The summit, flattened from before to behind and bevelled on its anterior face, joins the zygomatic process, and forms with it the *jugal bridge*, or *zygomatic arch*.

Structure and development.—This bone is rather spongy in its upper part, and is developed from a single nucleus of ossification.

Differential Characters in the Malar Bone of other Animals.

A. **Ox, Sheep, Goat.**—The malar bone of Ruminants is very developed. The zygomatic crest is no longer formed by the posterior border of the bone, but is carried to the posterior part of the external face, and runs parallel with the eyebrow. The summit is bifurcated, the

[1] This bone is the representative of the *internal wing* of the pterygoid process in Man.

anterior branch forming a buttress against the summit of the orbital process of the frontal bone, while the posterior articulates with the temporal. In these animals, the bone offers several centres of ossification.

B. **Camel.**—This bone is very little developed, and is compressed from before to behind. Its anterior face is very concave, and circumscribes the orbit posteriorly. Its posterior face considerably overhangs the maxillary bone, and forms a very salient zygomatic crest. The summit is bifurcated, as in the Ox.

C. **Pig.**—The summit of this bone in the Pig is flattened on each side, and divided into two branches, between which is wedged the summit of the zygomatic process; the anterior branch is very short, and does not join the frontal bone.

D. **Carnivora.**—The malar of the *Dog* and *Cat* only articulates with the supermaxillary bone, and by its base alone. The crest describes a curve, the concavity backwards, and the summit comports itself as in the Pig.

F. **Rabbit.**—The bone is flattened on both sides: the summit, united with the zygomatic process of the temporal bone, is single; while the base is confounded entirely with the malar tuberosity (Fig. 36).

6. Lachrymal Bone (Figs. 26, 51).

A small, thin, and very light bone, bent on itself at a right angle, it is situated beneath the orbit, which it aids in forming, and is wedged between the frontal, nasal, supermaxillary, and malar bones. It is studied on its *external* and *internal faces* and *circumference.*

Faces.—The *external* is divided into two regions, superior and inferior, by a curved crest which forms part of the orbital margin, and is provided with notches, which are variable in their form and number. The superior region, named the *orbital*, because of its situation in the orbit, is slightly concave and smooth. It presents, near the orbital margin, the orifice of the *lachrymal duct*, which traverses the maxillary sinus and opens on the internal face of the supermaxillary bone, where it is continued by a fissure; behind this is the *lachrymal fossa.* The inferior or *facial* region is slightly bulging, and provided sometimes with a tubercle for insertion,—the *lachrymal tubercle.* The *internal face* is employed, for the whole of its extent, in the formation of the walls of the maxillary and frontal sinuses; it exhibits a cylindrical prominence produced by the bony tube of the lachrymal duct.

Circumference.—This is very irregular, and denticulated for articulation with the neighbouring bones.

Structure and development.—This bone is entirely compact, and is developed from a single nucleus of ossification.

In the **Ass**, the lachrymal tubercle is placed towards the anterior border of the bone; usually, it partly belongs to the nasal bone, and is consequently found on the suture uniting the lachrymal bone to the proper bones of the nose.

Differential Characters in the Lachrymal Bone of other Animals.

A. **Ox, Sheep, Goat.**—The lachrymal bone, much more extensive than that of the Horse, forms in the bottom of the orbit an enormous protuberance, hollowed internally by the maxillary sinus, and the walls of which are so thin and fragile that the slightest jar is sufficient to cause their fracture (in the skeleton). It would be convenient to designate it the *lachrymal protuberance.*[1] In the smaller Ruminants, the inferior region of the internal face shows a depression—the *lachrymal fossa.*

B. **Camel.**—This bone is much smaller than in the Horse; its facial portion especially is almost rudimentary. There is no lachrymal protuberance nor tubercle, the latter being carried to the superior maxilla.

C. **Pig.**—In the *Pig* there are observed a lachrymal fossa and two lachrymal canals, which

[1] Girard, who named this eminence the *orbital protuberance,* wrongly described it as belonging to the supermaxillary bone.

are pierced outside the orbital cavity, and soon coalesce in the substance of the bone to constitute a single canal. The fossa is very deep.

D. **Carnivora.**—This bone in Carnivora is extremely small. Its external face entirely belongs to the orbit, and does not descend beneath the margin of that cavity; it has no lachrymal fossa. The reduced dimensions it presents in these animals well justifies the name, *os unguis*, given to it in anthropotomy.

7. Nasal Bones (Fig. 26).

Situated on the anterior aspect of the head, these bones articulate with each other in the median line, and are fixed between the frontal, lachrymal, and supermaxillary bones; they are triangular in shape, elongated from above to below, flattened from before to behind, and offer for study *two faces*, *two borders*, a *base*, and a *summit*.

Faces.—The *external* or *anterior face*, wider above than below, is convex from side to side, and almost smooth. The *posterior*, *internal*, or *nasal face* exhibits a vertical crest passing along the external border of the bone, which gives attachment to the turbinated portion of the ethmoid; at its superior extremity this crest bifurcates, and between its two branches shows a concave surface which forms part of the frontal sinus. For the remainder of its extent the internal face is smooth, and covered by the mucous membrane of the nasal fossa; it is also excavated into a channel to form the superior meatus of this cavity.

Borders.—The *external border* is very thin in its upper two-thirds, and articulates with the lachrymal bone, the anterior border of the supermaxillary, and the extremity of the external process of the premaxilla. In its lower third it becomes isolated from the latter bone, in forming with the anterior border of its large process a very acute re-entering angle, the opening of which looks downwards. The *internal border* is denticulated for contact with the opposite bone.

Base and Summit.—The *base* occupies the superior extremity of the bone; it describes a curved line with the convexity above, and, in uniting on the median line with that of the opposite bone, forms a notch similar to that of the heart figured on playing-cards; it is bevelled, at the expense of the internal plate, to articulate with the frontal bone. The *summit* of the two nasal bones, which is pointed, constitutes the *nasal prolongation*—the name given to a single triangular process which comprises all that portion of the nasal bones separated from the premaxillaries by the re-entering angle before mentioned.

Structure and development.—Almost entirely compact in structure, it is developed from a single centre.

Differential Characters in the Nasal Bones of other Animals.

A. **Ox, Sheep, Goat.**—The nasal bones of the *Ox* are never consolidated with each other, nor yet with the neighbouring bones. The external border only comes in contact to a small extent with the supermaxillary bone; the superior extremity is fixed in the notch of the inferior border of the frontal bone. At their inferior extremity, they each present a notch which divides them into two points.

In the *Sheep* and *Goat* the nasal spine is unifid, as in the Horse (see Figs. 30, 32).

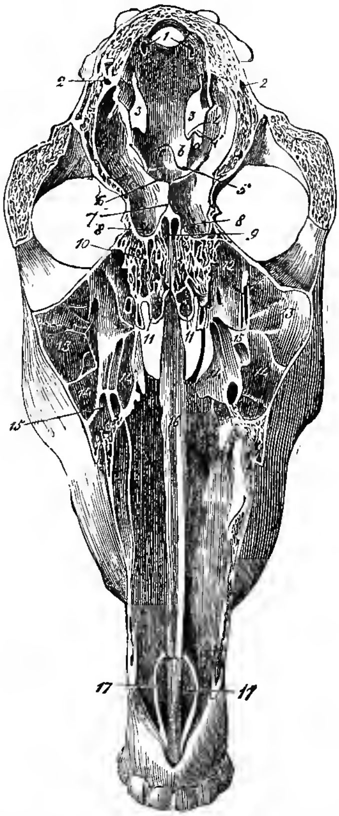
B. **Camel.**—In the *Camel*, the proper bones of the nose are short and narrow; their external border is in contact only with the superior maxilla; the upper extremity is rounded. At the inferior extremity, they show a well-marked notch, which divides them into two points, but the inner point is very small.

C. **Pig.**—These bones are long and narrow, and traversed on their external face by the fissure that descends from the supra-orbital foramen. The nasal prolongation is short.

D **Carnivora.**—The two bones of the nose are little developed, and are wider below than above; they have no nasal prolongation, but offer, instead, a semicircular notch.

E. Rabbit.—Proportionately long and wide, the nasal bone of the *Rabbit* articulates, by the whole of its external border, with the ascending process of the premaxillary bone. The anterior extremity of the nasal bone is very slightly salient.

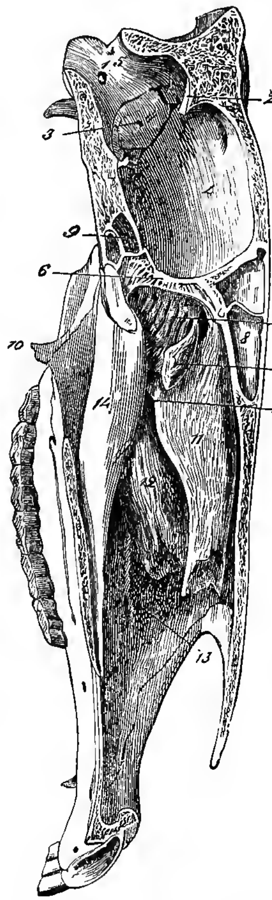
Fig. 41.



LONGITUDINAL AND TRANSVERSE SECTION OF THE HORSE'S HEAD, SHOWING THE FLOOR OF THE CRANIAL AND NASAL CAVITIES, WITH THE MAXILLARY SINUSES.

1, Condyloid foramen. 2, Section of the parieto temporal canal. 3, Foramen lacerum basis cranii. 4, Carotid notch. 4′, Maxillary notch : *a*, supermaxillary fissure ; *b*, cavernous fissure. 5, Origin of the supra-sphenoidal canals : *c*, sella Turcica. 6, Optic fossa. 7, Portion of the crista-galli process. 8, Cribriform plate of the ethmoid bone. 9, Perpendicular plate of the same bone. 10, 10, Its lateral masses. 11, Interior of the great ethmoidal cell. 12, 12, Bottom of the maxillary sinuses communicating with the sphenoidal sinuses. 13, Superior maxillary sinus. 14, Inferior maxillary sinus. 14′, Superior compartment of the maxillary turbinated bone, forming part of the latter sinus. 15, Section of the supermaxillo-dental canal. 16, Channel of the vomer. 17, Internal process, or point of the premaxillary bone.

Fig. 42.



ANTERO-POSTERIOR AND VERTICAL SECTION OF THE HORSE'S HEAD.

1, Condyloid foramen ; 2, parietal protuberance ; 3, internal auditory hiatus ; 4, cerebral cavity ; 5, cerebellar cavity ; 6, superior border of the perpendicular plate of the ethmoid bone (crista-galli process) ; 7, ethmoidal volutes—nasal face ; 8, vestiges of the right frontal sinus ; 9, ditto of the sphenoidal sinus ; 10, pterygoid process ; 11, ethmoidal turbinated bone ; 12, maxillary turbinated bone ; 13, crest of the supermaxillary bone to which the latter is fixed ; 14, vomer. A, Orifice of communication between the nasal cavity and the sinus.

8. Turbinated Bones (Fig. 42).

The *turbinated* (or *turbinal*) *bones*, two on each side, represent two irregular bony columns, wider above than below, compressed laterally, hollowed internally, and lying vertically side by side on the external wall of the nasal fossa, which they divide into three *meatuses* or passages.

They are distinguished into *anterior* and *posterior turbinated bones.*

The *anterior* or *superior*, also named the *ethmoidal*, is formed by a very thin plate of compact tissue—fragile and like papyrus, fixed by its anterior border to the internal crest of the nasal bone, and rolled on itself, from before to behind, in the same manner as the cells of the ethmoid bone. Above, it is confounded with the last-named bone, of which it is only, properly speaking, the most anterior volute. At its inferior extremity, it is prolonged by a fibro-cartilaginous framework to the external orifice of the nose.

Its internal cavity is partitioned by a transverse plate into two portions: the superior compartment forms part of the frontal sinus; the inferior is subdivided by other small lamellæ into a variable number of cells which communicate with the nasal cavity. This bone, developed from a single nucleus, is ossified at the same time, and in the same manner, as the ethmoidal cells. Before birth, it is already intimately consolidated with the nasal bone.

The *posterior*, *inferior*, or *maxillary turbinated bone* resembles the first, except in some particulars. Thus, its bony or proper portion is not so long or voluminous, while its cartilaginous part is, on the contrary, more developed. It is attached, by its posterior border, to the vertical and sinuous crest of the supermaxillary bone, and is rolled from behind to before, or in an inverse direction to the other. It has no connection with the ethmoid, and its superior cavity forms part of the inferior maxillary sinus. It is late in becoming ossified, and is scarcely united in a definite manner to the maxillary bone until the horse is about a year old.

The *meatuses* are distinguished into *anterior* or *superior*, *middle*, and *posterior* or *inferior*. The first passes along the front of the ethmoidal turbinated bone; the second separates the two turbinated bones, and presents, near its superior extremity, the opening communicating between the sinuses and the nasal cavities.[1] The third is situated behind the maxillary turbinated bone, and is confounded with the floor of the nasal fossa.

The turbinated bones are essentially disposed to furnish the membrane of the nose with a vast surface of development. This membrane, indeed, covers their entire superficies, and even penetrates the anfractuous cells of their lower compartment.

Differential Characters in the Turbinated Bones of other Animals.

A. **Ox, Sheep, Goat.**—In the *Ox* (Fig 43), the ethmoidal turbinated bone is very small, and is united to the nasal bone by the two borders of its osseous plate; its internal cavity entirely belongs to the frontal sinus. The maxillary turbinated bone is very developed, and is joined to the bone which sustains it at a later period than in the Horse. The bony lamina of which it is composed, is curved on itself in two different directions—from before to behind by its posterior border, and behind to before by its anterior border. It is fixed to the supermaxillary bone by its middle part, through the medium of a particular bony lamina, and it very incom-

[1] The two turbinated bones, in being applied against the excavation on the inner face of the supermaxillary, almost entirely close it, only leaving between them a vertical slit which constitutes the opening mentioned above.

pletely closes the excavation which concurs to form the maxillary sinus. In the skeleton there is also found behind, and at the base of this turbinated bone, a vast opening which is totally closed in the fresh condition by the pituitary membrane. The maxillary sinus is not prolonged in its interior. In the smaller Ruminants, the cavity of the sinus is closed by the maxillary turbinated bone in a more complete manner than in the Ox.

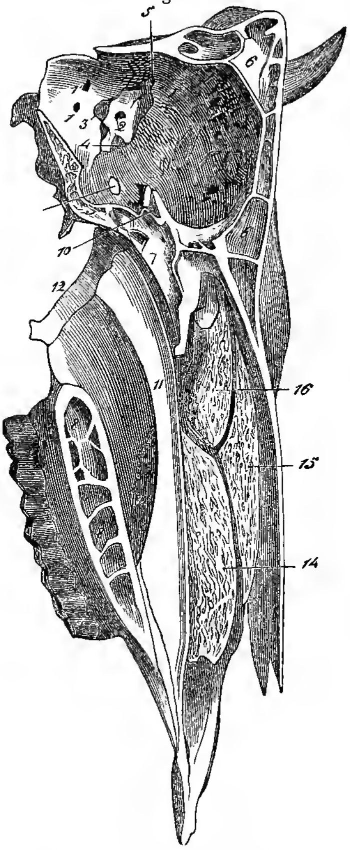
B. **Camel.**—The ethmoidal turbinated bone is very small. Otherwise it is as in the other Ruminants.

C. **Pig.**—The same arrangement as in the Sheep and Goat, except that the bones are much longer and less fragile.

D. **Carnivora.**—These bones in the *Dog* and *Cat* are particularly distinguished for their numerous convolutions. Neither participate in the formation of the frontal or maxillary sinuses; the latter is not in any way closed by the maxillary turbinated bone, but opens into the nasal cavity by a large gaping aperture.

E. **Rabbit.**—The bones are arranged as in the Dog, but the folds are less numerous.

Fig. 43.



MEDIAN AND VERTICAL SECTION OF THE OX'S HEAD.

1, Condyloid foramen; 1′, posterior orifice of the occipital lateral canal joining the parieto-temporal canal in front; 2, internal auditory hiatus; 3, anterior foramen lacerum; 4, posterior ditto; 5, intra-cranial orifice of the parieto-temporal canal; 6, 6, median bony plate separating the frontal sinuses; 7, lamina which isolates the sphenoidal sinus; 8, lamina partitioning the palatine portion of the maxilliary sinuses; 9, oval foramen; 10, optic fossa; 11, vomer; 12, pterygoid bone; 13, large opening leading into the maxillary sinus, and which, in the fresh state, is closed by the pituitary membrane; 14, maxillary turbinated bone; 15, ethmoidal turbinated bone; 16, great ethmoidal cell.

9. Vomer (Figs. 34, 38).

This, a single bone, elongated from above to below, flattened on both sides, and extending on the median line from the body of the sphenoid to the premaxillary bone, offers for study *two lateral faces*, *two borders*, and *two extremities*.

The *faces* are smooth, plane, and covered by the nasal membrane. The *anterior border* is channeled for the whole of its length by a deep groove, which receives the posterior border of the cartilaginous septum of the nose. The *posterior border* is sharp and smooth in its upper half, which separates the two guttural openings of the nasal cavities: it is thick and slightly denticulated for the remainder of its extent, and rests on the median suture resulting from the union of the two supermaxillary bones. The *superior extremity* is provided, in its middle, with a notch which divides it into two lateral prolongations shaped like a cat's ears (*wings of the vomer*); it articulates with the inferior sphenoid, ethmoid, palatine, and pterygoid bones. The *inferior* extremity rests on the prolongations of the premaxillæ.

This bone is entirely compact, and is developed from one centre of ossification.

Differential Characters in the Vomer of other Animals.

A. **Ox, Sheep, Goat.**—This is a very wide and thin bone, resting only on the lower half of the median suture of the premaxillaries (Fig. 43).

B. **Camel.**—Wider in its upper part than in the Ox, the vomer reaches, outwardly, the orbital cavity. By its inferior border, it rests on the entire length of the median suture of the palatine and supermaxillary bones.

C. **Pig.**—The vomer in this animal adheres to the bones of the palatine arch for a great extent. The free portion of the inferior border is short and but little prominent.

D. **Carnivora.**—In the *Dog* and *Cat*, the vomer is short, but its wings are very large.

10. Inferior Maxillary Bone (Fig. 44).

The *inferior maxillary bone* is not consolidated with any of the preceding bones, and is only united to two of them—the temporals—by diarthrodial articulation. It is a considerable bone, situated behind the upper jaw, and composed of two symmetrical branches, which are flattened on both sides, wider above than below, curved forwards in their upper third, joined at their lower extremities, and separated superiorly so as to leave a wide gap between them, like the letter V in shape, called the *intra-maxillary space.* Each offers for study *two faces, two borders*, and *two extremities.*

Faces.—The *external face* of the maxillary branches is smooth and rounded in its inferior two-thirds, and transformed superiorly into a rugged surface, in which is implanted the fibres of the masseter muscle. The *internal face* presents, in the corresponding point, an excavated surface on which is remarked the superior orifice of the *maxillo-dental canal*, a long channel which descends between the two plates of the branch, passing under the roots of the molar teeth, and insensibly disappearing in the body of the bone after being widely opened externally by the *mental* (or *anterior maxillary*) *foramen.* In its inferior two-thirds, the internal face is smooth, nearly plane, and shows nothing very remarkable. Near the alveolar border there is a slightly projecting line—the *myloid ridge;* and quite below, or rather at the very summit of the re-entering angle formed by the separation of the branches, there is a slight rugged excavation confounded with that of the opposite branch, and named the *genial surface.*

Borders.—The *anterior*, also named the *alveolar border*, exhibits for study a straight or inferior, and a curved or superior portion. The first is hollowed by six alveoli to receive the inferior molar teeth.

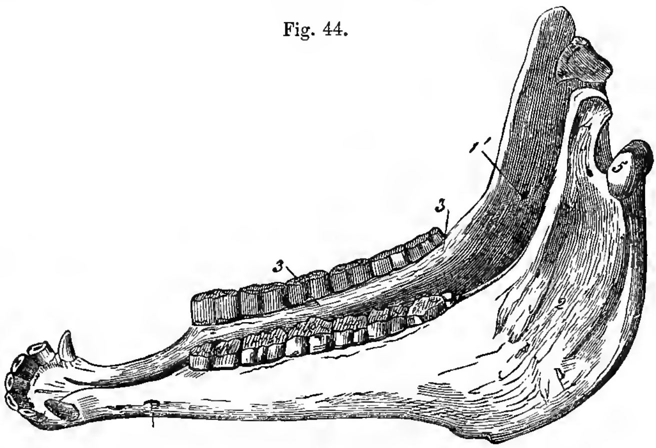
The second, thinner, concave, and rugged, serves for muscular insertion. The *posterior border* is also divided into straight and curved portions. The latter is convex, thick, rugged, and margined on each side by an uneven lip; the first is regularly rectilinear, so that all its points rest at the same time on a horizontal plane; it is thick and rounded in the young animal, but becomes sharp with age; an oblique and transverse fissure—the *maxillary*—separates it from the curved part. The union of these two portions forms the *angle* of the jaw.

Extremities.—The *superior extremity* has two eminences: a *condyle*, and a long non-articular process named the *coronoid process.* The condyle is elongated transversely, and convex in its two diameters; it responds, through the medium of a fibro-cartilaginous disc, to the articular surface of the zygomatic process. The coronoid process is situated in front of the condyle, from which it is separated by a division called the *sigmoid* or *corono-condyloid notch;* it is flattened on both sides, and curved backwards and slightly inwards.

From the union of the branches of the maxillary bone at their *inferior extremity*, results a single piece, flattened before and behind, and widened like a spatula, which has been designated the *body* of the bone. This merits a special description.

Its form allows us to divide it into an *anterior* or *buccal face*, a *posterior* or *labial face*, and a *circumference*. The *anterior face* is smooth and concave, is lined by the buccal mucous membrane, and supports the free extremity of the tongue. The *posterior face* is convex, more extensive than the preceding, and continuous with the external face of the branches. It presents: 1. On the median line, a slight crest or small groove—traces of its being originally separated into two pieces. 2. On the sides and above, the *mental foramen*—the inferior orifice of the maxillo-dental canal. On a level with this foramen, the bone very markedly contracts to form the *neck*. The *circumference* describes a parabolic curve, the concavity being uppermost, and joins, by its extremities, the anterior border of each branch. It is excavated in its middle part by the six alveoli for the lodgment of the inferior incisors, and behind these—in male animals only—there is an additional alveolus for the tusk. The portion included on each side

Fig. 44.



INFERIOR MAXILLA.

1, Mental foramen; 1′, superior orifice of the maxillo-dental canal; 2, surface of implantation for the masseter muscle; 3, myloid ridge; 4, coronoid process; 5, condyle.

between the last incisor and first molar, forms a more or less sharp ridge, which constitutes the *inferior interdental space* or *bar* (*diastema*).

Structure and development.—Formed, like all the flat bones, by two compact plates separated by spongy tissue, the inferior maxilla is developed from two centres of ossification, which correspond to each branch, and which coalesce some time after birth.

But in the human fœtus, there can be seen five pieces developed around the dental canal—the coronary, articular, angular, opercular, and premaxillary—which proves that the maxilla of Mammalia is formed on the same type as that of oviparous Vertebrata (Lavocat).

Differential Characters in the Inferior Maxilla of other Animals.

A. **Ox, Sheep, Goat.**—In these animals, the part of the posterior border of the inferior maxilla below the molars is convex, and cannot rest on a horizontal plane by all its points at the same time. The condyle is convex in its small diameter, and slightly concave laterally. The coronoid process is bent backwards and outwards. The body does not show any alveolus for the tusk, because this tooth is not present in these animals; but it is hollowed by eight alveoli for the incisor teeth. The two branches of the bone are never consolidated, but remain movable on each other during life.

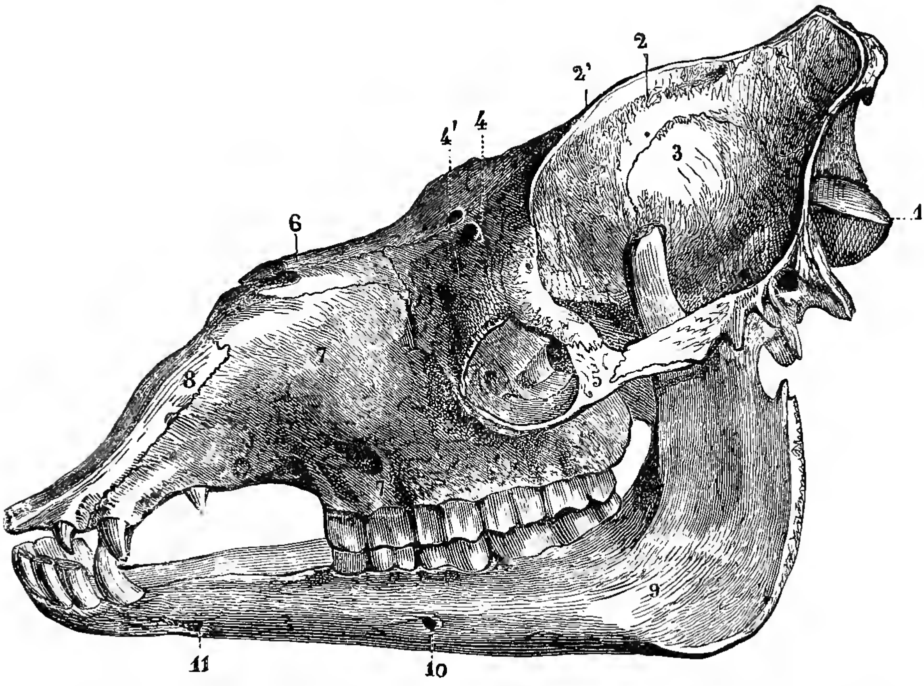
B. **Camel.**—The branches are short and thick, the body very long, and the interdental space considerable. The straight border of the branches has a posterior rectilinear border, as in the Horse; the anterior margin of the curved portion is thin and sharp. On its internal face is seen a plate in front of the superior opening of the inferior dental foramen, and a mylohyoid fissure.

The condyle is convex in front, flat and oblique behind. The coronoid process is very strong. Below the condyle is a process separated from the latter by a deep notch.

The circumference of the body is excavated by eight alveoli—six for the incisors, and two for the canines.

C. **Pig.**—A straight line leading from the greater axis of the alveoli of the molar would

Fig. 45.



HEAD OF THE CAMEL.

1, Occipital bone; 2′, parietal crest; 3, squamous temporal; 4, frontal bone; 4′, supra-orbital foramen; 5, malar bone; 6, nasal bones; 7, supermaxillary bone; 7′, infra-orbital foramen; 8, premaxillary bone; 9, inferior maxilla; 10, 11, openings of the inferior dental foramen.

not traverse the posterior border of the maxillary branches, the bottom of these alveoli corresponds to the relief on the inner face. The condyle is compressed on both sides, and elongated from before to behind; while the coronoid process is short and wide. There is no neck; the interdental spaces are very short; and the maxillo-dental canal opens inferiorly by multiple orifices.

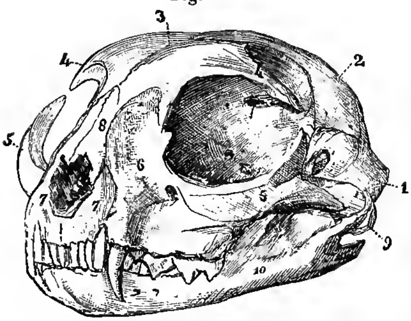
D. **Carnivora.**—In Carnivora, this is hollowed at the point corresponding to the insertion of the masseter muscle into a somewhat deep fossa. The posterior border is disposed as in Ruminants, and below the condyle has a very marked tuberosity. The condyle represents an ovoid segment, and fits exactly into the temporal cavity. The coronoid process is very strong, elevated, and wide. The mental foramina are double or treble. There are no interdental spaces, nor excavated surface on the inner face of the branches; and the latter are never consolidated.

E. **Rabbit.**—In the maxilla of the *Rabbit*, the coronoid process is very short, and the condyle narrow and elongated from before to behind. The posterior border is deeply notched in its curved portion; the interdental space is very long; and the body has only two alveoli for the incisors.

11.—The Hyoid Bone (Fig. 47).

The *hyoid bone* constitutes a small and special bony apparatus which serves to support the tongue, as well as the larynx and pharynx; its description is placed immediately after that of the bones of the head because of its connection with that region, it being situated between the two branches of the supermaxillary bone, and suspended from the base of the cranium in an oblique direction from above to below, and from before to behind.

Fig. 46.



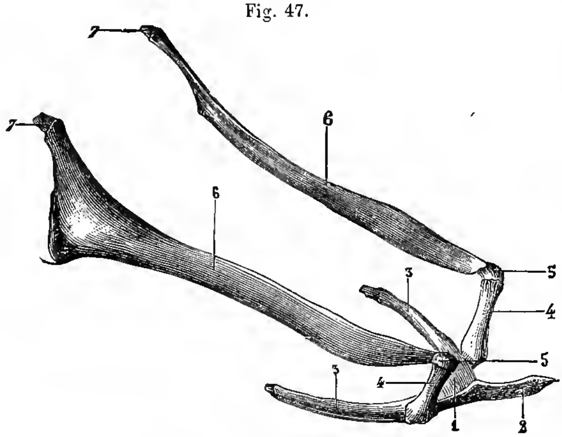
HEAD OF THE CAT.

1, Parieto-occipital suture; 2, parietal bone; 3, frontal bone; 4, orbital process of the frontal bone; 5, malar bone; 6, supermaxillary bone; 7, 7, premaxilla; 8, nasal bone; 9, tympanic bulb; 10, inferior maxilla.

This apparatus is composed of seven distinct pieces, arranged in three series: a middle, constituted by a single bone, and named the *body*; two lateral, forming two quasi-parallel *branches*, to the extremities of which the body is articulated.

Body or *basihyal*.—The body of the hyoid resembles a fork with two prongs. It presents: 1. A middle part flattened above and below, and conseqnently provided with a superior and an inferior face. 2. A single and long prolongation flattened on both sides, which is detached from the middle part, and directed forward and downward to plunge into the muscular tissue of the tongue: this is the *anterior appendix of the hyoideal body*, or *lingual prolongation*. 3. *Two lateral cornua, thyroid cornua, great cornua*, or *urohyals*, projecting backwards and upwards, articulating by their extremities with the thyroid cartilage of the larynx, and offering, at their point of union with the middle part, two convex diarthrodial facets looking upwards, and corresponding with the *styloid cornua*. The body of the hyoid bone is developed by three centres of ossification—a middle, and two lateral for the cornua.

Fig. 47.



HYOID BONE OF THE HORSE.

1, Body or basihyal; 2, lingual prolongation; 3, 3, thyroid cornua, great cornua, or urohyals; 4, 4, styloid cornua, small cornua, or apohyals; 5, 5, styloid nuclei or ceratohyals; 6, 6, styloids, great hyoideal branches, or stylohyals; 7, 7, arthrohyals, or cartilaginous nuclei attaching the hyoid to the temporal bone.

Branches.—The three pieces composing these are articulated end to end, by means of a cartilaginous substance that joins them together; they are of very unequal dimensions. The first, which is in relation with the body, is of medium size, and is named the *styloid cornu*, *small cornu*, or *small branch*. The second, termed the *styloid nucleus*, is the smallest. The third, the largest, constitutes the *styloid process* or *bone*, or *great branch*.

1. The *styloid cornua* (*apohyal*) is a small cylindrical piece bearing a concave diarthrodial surface on its inferior extremity to unite it to the body; it is very spongy, and is developed from two ossifying centres, one of which, the epiphysary, is for the inferior extremity.

2. The *styloid nucleus* (*ceratohyal*), which is often absent, is embedded in the uniting cartilaginous substance.

3. The *styloid bone*, or *great hyoideal branch* (*stylohyal*), is long, thin, flattened on both sides, and directed obliquely from above to below, and before to behind; it presents two faces, two borders, and two extremities. The faces—an external and internal—are marked by some few imprints. The anterior border is sharp and slightly concave in its upper third. The posterior border is thicker, and is divided into two portions—a superior or horizontal, which is very short, and an inferior or vertical, much more extensive. The angle they form at their point of junction presents a salient, and more or less roughened, tuberosity. The superior extremity is united to the hyoideal prolongation of the temporal bone by means of a cylindrical fibro-cartilage. By its inferior extremity, the *styloid bone* is united either to the styloid nucleus or the styloid cornu, forming a sharp elbow directed forwards. The styloid bone, developed from a single centre of ossification, is almost entirely formed of compact tissue.

Differential Characters of the Hyoid Bone in other Animals.

A. **Ox, Sheep, Goat.**—The hyoid bone of Ruminants is always composed of seven pieces; the styloid nucleus, the presence of which is not constant in Solipeds, is never absent in these, and has the proportions of the second small branch. The anterior appendix is very short, and only represents a large mamelon.

B. **Camel.**—The hyoid is in this animal as in the Ox.

C. **Pig.**—The body is voluminous and deprived of an appendix; the small branches are short and consolidated with the body; while the large branches, curved like an S, are very thin, and are not united to the small branches and the temporal bone by fibro-cartilage, but by veritable yellow elastic ligaments.

D. **Carnivora.**—The three pieces composing the body of the hyoid in early life are never consolidated in the adult animal, but always remain isolated, as in Man. The middle piece has no anterior appendix; the fibro-cartilages uniting the styloid portions to each other and to the temporal bone are very long and flexible.

12. Wormian Bones (Fig. 48).

This name has been given to small irregular bones which Worms observed between some of the sutures of the cranial bones. They are developed after birth, in the cranial, cranio-facial, and facial sutures. Their number and position varies with the species of animals, and even the breeds of the same species.

Vaguely described by Rigot, they have been recently studied by Cornevin, who observes that the cranial Wormian bones are rare. In more than sixty crania, they were found only once or twice in the Ox and Horse at the junction of the petrous with the occipital bone. The Wormian bones of the cranio-facial and the facial suture are more frequent; nevertheless, they have been met with almost exclusively in the heads of common-bred animals, particularly in the bovine species. Cornevin has described a fontanelle lachrymo-nasal bone (Fig.

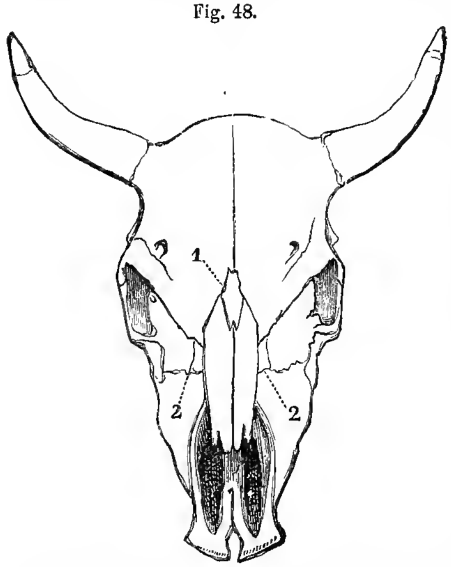
48, 2), and Wormian fronto-nasal (Fig. 48, 1), as well as an internasal, orbital, zygomato-maxillary, maxillo-nasal-incisive bone. (Sometimes two Wormian bones are found in the same head.)

OF THE HEAD IN GENERAL.

1. General Configuration.

From the union of all the bones which constitute the cranium and face, there results a quadrangular pyramid, with summit inverted, which it is necessary to study as a whole. We will pass in review, successively, its *four faces*, its *base*, and its *summit*.

Fig. 48.



WORMIAN BONES OF THE OX. (AFTER CORNEVIN.)
1, Fronto-nasal Wormian bones; 2, 2, lachrymo-nasal fontanellar bones.

A. **Anterior Face.**—This is subdivided into four regions (Fig. 49):

1. *Parietal region.*—This has for base the anterior portion of the occipital bone and the parietal bones. Limited, above, by the *external occipital tuberosity*, it presents on the middle line a spur which soon bifurcates to form the *parietal* or *temporal crests*; the latter join the posterior border of the zygomatic process.

2. *Frontal region.*—Larger than the preceding, it is usually plane and lozenge-shaped. Bounded inferiorly by the fronto-nasal suture, this region projects, laterally, the *orbital processes*, the base of which is pierced by the *supra-orbital foramen*, and the anterior border—somewhat sharp—is frequently made irregular by small notches, one of which is often converted into a foramen.

3. *Nasal region.*—This region has for its base the proper bones of the nose. It is narrow, convex on each side, and plane, concave, or convex in its length, according to the animals. It advances above the entrance to the nasal cavities, where it forms the *nasal prolongation*, the summit of which, in the Horse, ceases at nearly two fingers' breadth from the intermaxillary symphysis.

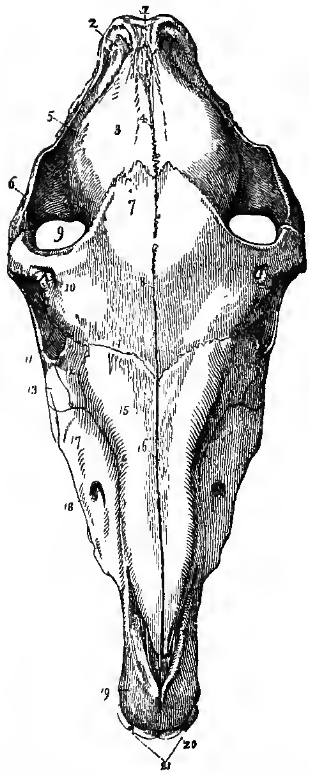
4. *Incisive region.*—Principally formed by the incisive bones, this region presents: the *inferior opening of the nasal cavities*, divided in the fresh state by the median cartilaginous septum of the nose; the *incisive slits* on the floor of the nasal fossæ; the *intermaxillary symphysis*, channeled above by a more or less deep groove in nearly all Horses, but raised, on the contrary, into a conical tubercle in the Ass and Hinny, and perforated in the middle by the *incisive canal.* Right and left of the intermaxillary symphysis this region is convex, and elevated by the prominence which the roots of the incisor teeth form.

B. **Posterior Face.**—In this are recognized four distinct regions (Fig. 50):

1. *Sub-occipital region.*—This presents: in the middle, the *basilar process*,

a strong piece more or less deeply channeled, according to the animals, and provided at its inferior extremity with rugosities for the attachment of the anterior straight muscles of the head ; on the sides, the lacerated foramina—large irregular

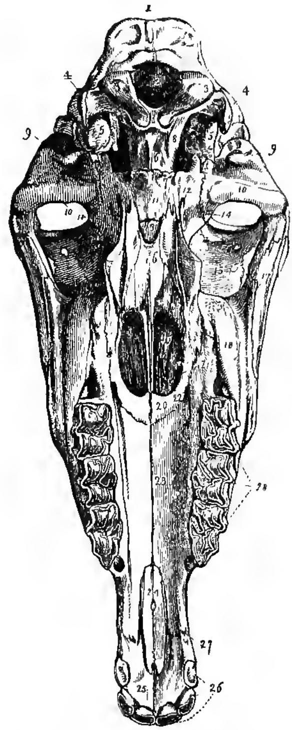
Fig. 49.



HORSE'S HEAD (ANTERIOR FACE).

1, Occipital tuberosity; 2, origin of the mastoid crest; 3, parietal bone; 4, saggital suture; 5, junction of the parietal and temporal bones; 6, zygomatic arch; 7, frontal bone; 8, frontal suture; 9, temporal fossa; 10, supra-orbital foramen; 11, 12, lachrymal bone; 13, malar bone; 14, nasal border of frontal bone; 15, nasal bone; 16, suture of nasal bones; 17, supermaxillary bone; 18, infra-orbital foramen; 19, anterior, or premaxillary bone; 20, foramen incisivum; 21, incisor teeth (young mouth).

Fig. 50.



HORSE'S HEAD (POSTERIOR FACE).

1, Occipital tuberosity; 2, foramen magnum; 3, 3, occipital condyles; 4, 4, styloid processes; 5, 5, petrous bone; 6, basilar process; 7, pterygoid fissure of the sphenoid bone; 8, foramen lacerum; 9, 9, supra-condyloid, or anterior mastoid process; 10, 10, articular eminence, or temporal condyle; 11, body of sphenoid bone; 12, pterygoid process; 13, ethmoid bone; 14, temporal bone and sphenoidal suture; 15, lachrymal bone; 16, vomer; 17, malar bone; 18, maxillary tuberosity; 19, posterior, or guttural opening of the nose; 20, palate bone; 21, palatine styloid process; 22, palato-maxillary foramen; 23, palatine process of superior maxillary bone, with suture; 24, ditto of premaxillary bone; 25, premaxillary bone; 26, upper incisor teeth; 27, point of junction of the premaxillary with the superior maxillary bone; 28, upper molar teeth (young mouth).

openings divided, in the fresh state, into two portions (*anterior* and *posterior lacerated foramina*). To the outside of these openings is the base of the tuberous portion of the temporal bones, especially the *tympanic bulb* or *petrous bone*; above are the *condyloid fossæ* with their *condyloid foramen*, and the *styloid processes of the occipital bone* or *jugular eminences*.

2. *Subsphenoidal region.*—This region is notably constricted in its middle part, where it has for base the body of the posterior sphenoid bone ; it is enlarged above by the temporal articular surfaces. It is limited by the inferior border of the foramen lacerum, on which are three notches transformed into foramina by the tissue that partitions the foramen lacerum basis cranii in the fresh state. These openings are, passing from within to without, the *carotid* or *cavernous foramen*, the *foramen ovale* or *foramen rotundum ;* they are all preceded by a groove on the surface of the bone. On each side of the body of the sphenoid is the narrow *Vidian fissure*, prolonged by the *Vidian canal*, and margined outwardly by the origin of the *subsphenoidal process*. Laterally, is the *subsphenoidal canal* for the passage of the internal maxillary artery, which is continued forward by two branches, one of which opens into the orbital hiatus, the other into the temporal fossa.

3. *Spheno-palatine region.*—This extends from the superior sphenoid to the palatine arch. In the median plane it shows a vast elliptical opening—the *guttural opening of the nasal cavities*, divided at the bottom into two portions by the vomer, and bordered laterally by two elevated crests (*pterygo-palatines*) resulting from the junction of the pterygoids with the palatine crests ; and limited in front by the posterior border of the palatine bones, which is raised in its middle by a blunt point directed backwards—the *nasal spine*. Beyond the pterygo-palatine crests is a slightly depressed surface, on which run the branches of the internal maxillary artery and the superior maxillary nerve. This surface extends, above, to the *orbital* or *sphenoidal hiatus*, below to the *maxillary hiatus*. In the maxillary hiatus are : the upper opening of the *superior dental canal*, the *palatine canal*, and the *nasal foramen*. In passing from the maxillary hiatus on the margin of the guttural opening of the uasal cavities, we meet with the *staphyline fissure*, which is limited above by the *alveolar tuberosity*.

4. *Palatine region.*—This is a wide elongated surface, limited laterally by the molar teeth and interdental spaces, and in front by the incisors. It shows : in the middle, the *palatine and superior maxillary suture*, which terminates at the incisive canal ; on the sides and above, the inferior opening of the *palatine grooves*, prolonged by the *palatine fissures ;* in front, the *incisive slits*.

C. **Lateral Face.**—This is a pair face, and comprises three regions (Fig. 51) :

1. *Maxillary region.*—This is very extensive. Its shape is triangular, base superior—the supermaxilla being joined to the premaxilla. Proceeding backward, there are observed : a fossa, in which opens the *infra-orbital foramen ;* the lower orifice of the superior dental canal, pierced above the third molar tooth ; the *malar* or zygomatic spine—a long vertical crest for the insertion of the masseter muscle, commencing above the fourth molar teeth, and continuing upwards with the malar bone and zygomatic process. Lastly, the maxillary region is limited, above, by the orbit and the *maxillary tuberosity*.

2. *Orbital region.*—This includes the *orbit* or *orbital* cavity, for the reception of the essential and some of the accessory organs of vision. In Man and the Quadrumana this cavity has complete bony walls, but in the domestic animals it always largely communicates with the temporal fossa, and it is not always even circumscribed at its opening by a solid ring. A fibrous lining (*ocular sheath*) converts it into a distinct cavity.

In the *Horse*, the outline of the orbit is constituted : below, by the lachrymal bone; above and in front, by the frontal bone and its process; externally, by the malar bone. If its two largest diameters are measured, it is remarked that this opening is scarcely ever regularly circular, its width varying from above to below or from without to within. With nine Horses' heads of various ages and breeds, equal diameters were found in only one, the other eight being unequal; of these, the vertical diameter of the orbit predominated in five, and was least in three.

In the *Ass*, as a general rule the vertical diameter is smallest, the relation between the two diameters varying from 1·09 to 1·15. Otherwise, the entrance to the orbit is irregularly square, and the orbital process which covers it is much wider and more salient than in the Horse—as Lecoq asserted, and as the observatious of Goubaux and Sansoń have confirmed. We have also noticed these differences, and they are not the only ones which permit the skeleton of the Ass to be recognized; for there have been already cited those of the spine and bones of the head—such as the articular depression surrounding the basilar process, the vascular furrow on the styloid process, the position of the lachrymal tubercle, and the conical eminence surmounting the premaxillary symphysis, above the incisive foramen; others will be noted hereafter (Figs. 51, 52).

With regard to the cavity of the orbit, it is separated from the maxillary hiatus and the temporal fossa by two linear imprints, diverging forwards, to which the ocular sheath is attached. It presents, on its floor, the upper orifice of the *lachrymal canal*, the *lachrymal fossa*, where the small oblique muscle of the eye has its fixed insertion; and within this, but higher, the little depression for the bend of the great oblique muscle of the eye.

3. *Temporal region.*—This region is more extensive than the preceding, and is composed of three principal parts—the temporal fossa, zygomatic arch, and petrous portion of the temporal bone.

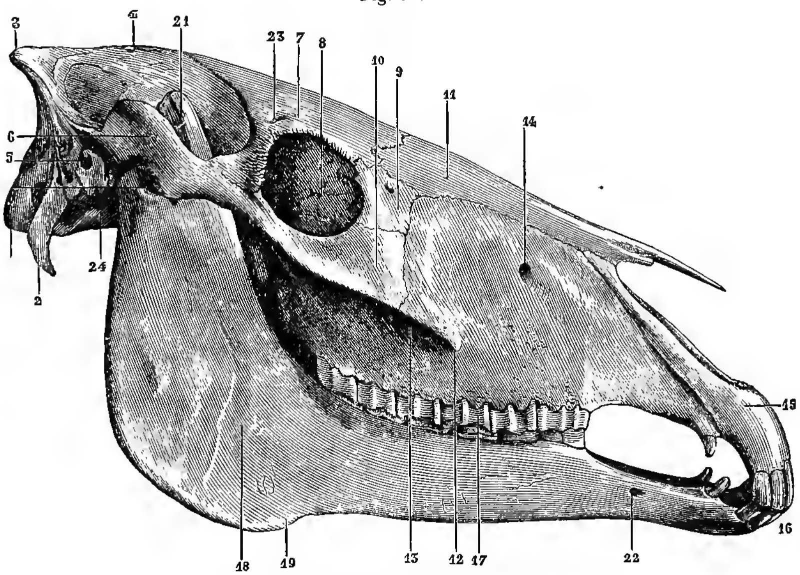
The *temporal fossa* surmounts the orbit, from which it is incompletely separated in Solipeds and Ruminants by the orbital arch; in the other domestic animals, this arch is incomplete in such a way, that in the skull the temporal fossa is confounded for the greater part with the orbit. Situated obliquely downwards and outwards on the sides of the cranium, the temporal fossa is oval in shape, and bounded inwardly by the occipital or temporal crest, outwardly by the anterior border and longitudinal root of the zygomatic process. It lodges the temporalis muscle; consequently, its width in our animals is proportionate to the power of that muscle. It is studded with muscular imprints, and has several vascular foramina which enter the parieto-temporal canal.

The *zygomatic arch* is formed as if by a loop thrown from the cranium on to the face, outside the temporal fossa and the orbit. It is constituted by the zygomatic process of the temporal bone and the malar bone, which latter prolongs it to the maxillary region.

The *tuberosity of the temporal bone* shows, outwardly, the external auditory canal, usually larger in the Ass than the Horse. Between this orifice and the supra-condyloid eminence is the opening of the parieto-temporal canal; and behind the latter are several irregular ridges, one of them being the *hyoid process.* The external face of the tympanic case is also studded with some *styloid prolongations*, one of which, more developed than the others, serves for the insertion of the peristaphyline muscles. Above the hyoid process is the *mastoid process*, and between these two parts is the *external orifice of the aqueduct of Fallopius.* From the mastoid process extends the *mastoid crest*, the summit of which meets the external occipital protuberance; it is crossed by the *mastoid groove*, which gives the mastoid artery passage to the parieto-temporal canal. All of the petrous portion is surrounded by deep clefts, resulting from the simple union of this bone with its neighbouring pieces.

D. **Base.**—The base or superior extremity of the head, formed by the occipital bone, represents a trapezoid surface, incurvated from before to behind. It is separated from the anterior face by the *external occipital tuberosity*, the projection of which is always greater in the Ass and Mule than in the Horse, with the exception of the English Horse, in which it has been found very developed (Figs. 51, 52). It is separated from the lateral faces by two crests—

Fig. 51.



HORSE'S HEAD (LATERAL FACE).

1, Occipital condyle; 2, styloid process of the occipital bone; 3, external occipital tuberosity; 4, parietal crest; 5, external auditory hiatus; 6, zygomatic process of the temporal bone; 7, frontal bone; 8, orbit; 9, lachrymal bone and its tubercle; 10, zygomatic or malar bone; 11, nasal bone; 12, supermaxillary bone; 13, zygomatic spine; 14, infra-orbital foramen; 15, premaxillary or intermaxillary bone; 16, incisor teeth; 17, molar teeth; 18, inferior maxilla; 19, maxillary fissure; 20, maxillary condyle; 21, coronoid process of the maxilla; 22, mental foramen; 23, supra-orbital foramen; 24, basilar process of the occipital bone.

the *superior curved lines*—which are prolonged backwards on the styloid processes of the occipital bone.

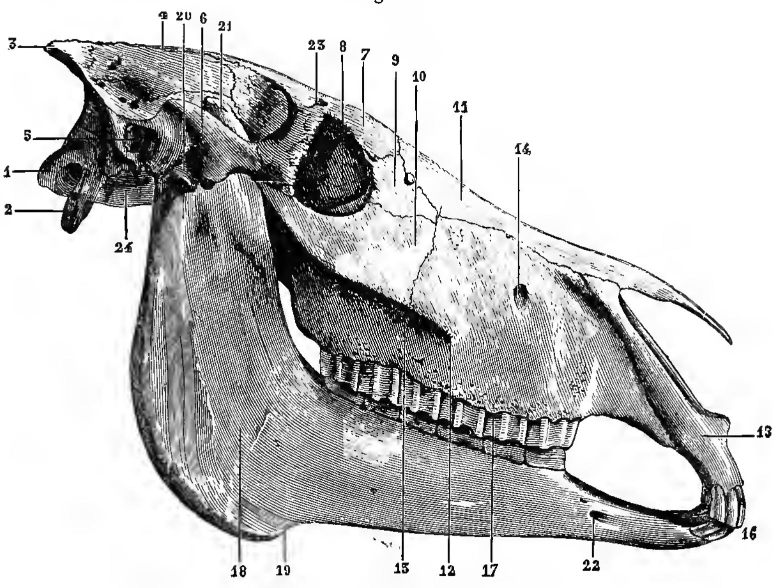
In the middle plane is the *occipital crest*, behind the tuberosity; it terminates, in becoming gradually effaced, at the *occipital foramen*, which is bordered on each side by the condyles of the occiput. The condyles are separated from the styloid processes by two deep notches—the *stylo-condyloid notches*. Between the middle line and the superior curved lines, are muscular imprints irregularly arranged in a half-circle—these are the *inferior curved lines*.

The base of the skull joins the anterior and posterior faces in forming angles; these possess some interest, as they may afford an important differential character between the Ass and Horse.

If one of the branches of a goniometer be placed tangentially to the surface of the basilar process, and the other to the summit of the external occipital tuberosity, the basilo-occipital angle will be obtained. In the measurements we have taken of eight heads of Horses of diverse ages and breeds, this angle has varied from 70° to 91°. We except the head of a young English Stallion, the basilo-occipital angle of which was from 92° to 100°. Measurement of the heads of Asses showed the angle to be 103°. The average basilo-occipital angle was 85·36° for the *Horse*, and 95° for the *Ass*.

If, instead of taking the basilo-occipital angle, the goniometer be applied to the origin of the temporal crests and the superior outline of the occipital

Fig. 52.



ASS'S HEAD (LATERAL FACE).

1, Occipital condyle; 2, styloid process of the occipital bone, with a very marked furrow on its external face; 3, external occipital tuberosity, more developed than in the horse; 4, parietal crest; 5, external auditory hiatus; 6, zygomatic process of the temporal bone; 7, frontal bone; 8, orbit, with its external outline more angular than in the horse; 9, lachrymal bone, with its tubercle partly implanted on the nasal bone; 10, zygomatic or malar bone; 11, nasal bone; 12, supermaxilla; 13, zygomatic spine; 14, infra-orbital foramen; 15, premaxillary bone, with its inner border raised by a salient tubercle above the incisive canal; 16, incisor teeth; 17, molar teeth; 18, inferior maxilla; 19, maxillary fissure; 20, maxillary condyle; 21, coronoid process; 22, mental foramen; 23, supra-orbital foramen, carried more to the middle of the orbital process than in the horse; 24, basilar process of the occipital bone.

foramen, the *parieto-occipital angle* is obtained. In the Horse, this angle is between 81° and 104°; in the Ass between 77° and 87°—the average being 91·12° for the *Horse*, and 84° for the *Ass*.

It was foreseen that the value of these angles would be in inverse relation. In all cases when, on a head, the basilo-occipital angle was found very open and the parieto-occipital more closed, combined with a great development of the external occipital tuberosity and the differential characters already described, it was certain to be the head of an *Ass*. In the English Horse, the external occipital tuberosity of which is very developed, the two angles in question are nearly equal. In the *Mule* and *Hinny*, the value of the angles is intermediate between the Horse and Ass. In the Mule, the mean value has been 86·12° for the basilo-occipital angle, and 88° for the parieto-occipital angle. In the Hinny, it was 87° for the first, and 81° for the second.

E. **Summit.**—This results from the union of the four faces; but, instead of being acute, it is flattened from behind to before, curved from side to side, and furnished with the incisor teeth.[1]

2. Conformation of the Cranium in Particular.

Retzius was the first to start the idea of considering the cranium of Man independently of the face. He distinguished the races of mankind as *brachycephalic* (short-headed), and *dolichocephalic* (long-headed)—that is, crania long from before to behind, and crania relatively short. Broca more recently compared the transverse diameter of the cranium with the antero-posterior diameter taken as a unit, and has expressed this relation in hundredths by the term *cephalic index*. For some years, Sanson has endeavoured to introduce into the classification of animals the calculations of Retzius and Broca. Taking the dimensions of the cranium as a basis, he has divided Horses into two groups—the brachycephalic and the dolichocephalic kinds.

If the cerebral cranial cavity—the only important one for this purpose—be enclosed in a parallelogram, two sides of which shall be at a tangent to the most salient points of the parietal bones, and the other two pass in front of the external auditory canals and across the supra-orbital foramina, the dimensions of the base and height of this parallelogram, *measured in a straight line*, will correspond to the longitudinal and transverse diameters of the cranium. In proceeding thus, Sanson has found that in certain crania the transverse diameter is greater than the longitudinal (*brachycephalic crania*), while in certain others the transverse is shorter than the longitudinal diameter (*dolichocephalic crania*).[2]

Toussaint took direct measurements of the interior of the cranium, and, no matter what the breeds of horses were which he examined, he always observed that the longitudinal diameter exceeded the transverse. We have made craniometrical investigations on a number of Horses, and are able to confirm Toussaint's statements. In eight skulls from different sources, the longitudinal diameter varied between 113 and 133 millimetres, the transverse between 88 and 104 millimetres. Consequently, in none of these animals was the transverse diameter equal to the longitudinal. In the number examined were the skulls of a Syrian and an English stallion—types which Sanson would have selected as the most brachycephalic; the relations between the length and width were 1·17 for the first, and 1·31 for the second. The average for the eight heads was 1·24.

We are of opinion that there are no brachycephalic Horses, in the rigorous sense of the word, such as Sanson admits; so that, if it is attempted to establish brachycephalic and dolichocephalic types, it will be necessary to previously fix what shall be the limit between these two types, and this has not yet been done.

The crania of Asses from the south of France are longer than that of the

[1] For the regions of the head, see Lavocat's *Nouvelle Ostéologie comparée de la tête des Animaux Domestiques.*

[2] *Sanson*, "Mémoire sur la Nouvelle détermination d'un type specific de race Chevaline," *Journal de l'Anatomie et de la Physiologie*, de Ch. Robin, 1867; also the later works of M. Sanson.

Horse; for in eight the average relation between the length and width was 1·25, instead of 1·24—a difference not very great, certainly. The difference becomes more marked, however, between the *Ass* and *Horse*, if the length of the cerebral be compared with that of the cerebellar cavity. This comparison has yielded an average of 1·962 in the Horse, and 1·927 in the Ass—which proves that the cerebellar cranium is longer in the Ass than the Horse.

The cranium is, as it were, strangled behind the orbital processes of the frontal bones. In glancing at the cranium of the Horse and Ass, it would at first appear that that of the *Ass* is relatively narrower than the cranium of the *Horse*. We have measured six heads of each species for the width of the cranium at its greatest diameter, behind the orbital processes, and, in comparing these two diameters, have obtained the following results: in the Horse, the relation varied between 1·18 and 1·27; in the Ass, between 1·20 and 1·47. The average has been, for the Horse, 1·226, and 1·335 for the Ass. From these figures, it might be concluded that the cranium of the *Ass* is relatively more constricted at its inferior extremity than that of the *Horse*. In the hybrids of the Horse and Ass, the cranial cavity is more elongated, and in this respect the Hinny more resembles the Ass than the Horse. With regard to narrowness of the cranium behind the orbital processes, the *Mule* holds the middle place between its parents, while the Hinny comes nearest to the Ass—the reverse of what is noticed in the development of the cerebellar cranium.

In Ruminants, the shape of the cranium is more or less masked by the frontal or parietal sinuses; consequently, it is difficult to study satisfactorily this part of the head, particularly in the bovine species.

The cranium of the domestic Dog offers great varieties; for the creation of numerous breeds has brought about important differences in the form and dimensions of this part, which it is impossible to deal with here.

3. Relations between the Cranium and Face.

Instead of studying the cranium alone, we may compare it with the face in regard to width, length, and the area that each of these two regions occupies in a vertical and median section. We may also, in measuring the *facial angle*, form an idea of the manner in which these two regions unite to form the head.

1. The forehead, properly speaking, measured from the union of the parietal crests to the fronto-nasal suture, is always, in the Horse, longer than the cerebral cranium, the second to the first being as 1 : 1·425. The forehead of the *Ass* is proportionately less developed, for we have found that the cranium is to the forehead as 1 : 1·265.

2. This shortness of the *Ass's* forehead, which renders the head heavy, is corrected by its narrowness; the head enlarges at the orbital processes. In comparing the distance between the supra-orbital foramina and the transverse diameter of the cerebral cavity, it has been noted that the width of the cranium is to the space between these foramina as 1 : 1·454 in the *Horse*, and 1 : 1·265 in the *Ass*. The forehead of the Ass is, therefore, in proportion to the cranium, shorter and narrower than in the horse. From this point of view, the heads of the *Mule* and *Hinny* are intermediate to those of their parents; but the first of these hybrids is nearer the Horse, and the second approaches the Ass.

3. Cuvier imagined that one of the means of judging of the intelligence of animals, would be to compare the area of the cranium with that of the face, measured on a median section of the head, deprived of the lower jaw. This

great naturalist remarked that the area of the cranium diminishes as the animals are further removed from the human type, while the area of the face increases in the same sense. Colin has studied the heads of the domesticated animals from this point of view. Putting to one side the surface occupied by the sinuses, he found that the area of the cranium to the face was as—

1 : 2·69 in the Horse.	1 : 3·24 in the Pig.
1 : 2·09 in the Ass.	1 : 1·17 in the Dog.
1 : 3·43 in the Ox.	1 : 0·68 in the Cat.
1 : 2·20 in the Ram.	1 : 1·47 in the Rabbit.
1 : 1·95 in the Goat.	1 . 0·54 in the Lamb.

From this table it will be seen that, if the domesticated animals are classified according to the area of the cranium, they will stand in the following order: Cat, Dog, Rabbit, Goat, Ass, Ram, Horse, Pig, and Ox.

4. Camper measured the *facial angle* by drawing two lines, starting from the entrance to the nasal cavities, and passing towards the middle of the external auditory canal and towards the most prominent part of the forehead. The facial angle gives an idea as to the relative volume of the face and cranium, and the dimensions of the latter; but with animals it furnishes very imperfect information, because of the form of the face and the development of the sinuses around the cranial cavity.

Colin has measured the facial angle of the domestic animals, by drawing two lines from the upper incisors towards the external auditory canal and the forehead, in the point corresponding to the lower end of the brain; and he obtained the following average values: from 12° to 15° for the Horse; 16° for the Ass; 20° for the Bull; from 20° to 25° for the Ram; from 34° to 41° for Dogs; and 41° for the Cat.

On the other hand, we have measured this angle in Equines, and find that it varies: in the Horse, between 11° and 13°; in the Ass, between 12° and 16°; and in the Mule, between 13° and 15°. In the Hinny, it measures 14°. It is somewhat remarkable that, in the Equidæ, the Ass should have a greater facial angle than the Horse.

4. Modifications due to Age.

Age brings modifications bearing upon the form of some regions of the head, the development of external peculiarities of the bones, the shape of the cranium, and its relations with the surface.

1. It has been remarked that the development of the occipital tuberosity, the temporal crests, and the lachrymal tubercle, increases with age in the Equine species; the infra-orbital foramen, which is frequently only a notch in youth, becomes a true foramen when the animal is advanced in age. In the Foal, the forehead is convex; that bone and the nasal bones become flat as the creature grows, and sometimes even the line of the nasal bones is concave in old age. The maxillary region, which is at first convex, becomes gradually hollow as the molar teeth are pushed out of the alveoli; while the straight part of the posterior border of the inferior maxilla becomes thin and sharp in very old Horses. The entrance to the orbit is also notably modified, though its shape is not identical in all the animals. In every instance, it has been remarked that the direction of the larger axis of the orbital cavity, comprised at first in the plane which passes by the auditory canal and the implantation of the upper incisors, is depressed in

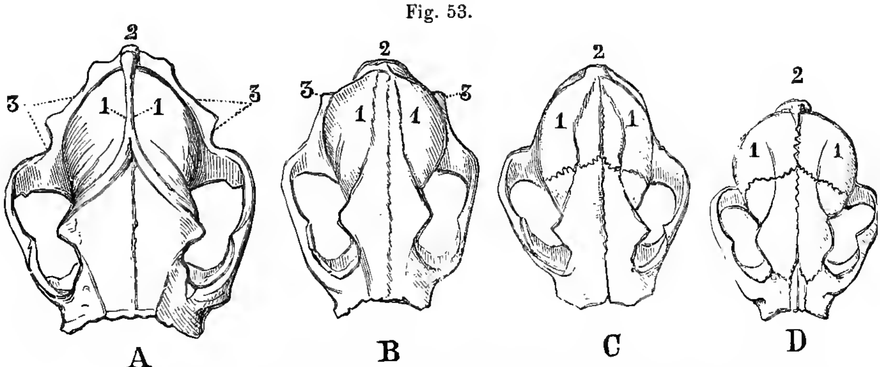
front, and at an advanced age is found in a plane passing by the inferior extremity of the zygomatic crest and the summit of the external occipital tuberosity.

2. If the cranium be examined by itself, it will be noted that, in proportion, it is less narrowed behind the orbital processes in the youug animal than in the adult. With regard to the cerebellar cranium, it is elongated when the animal is aged—a consequence of the natural development of the external occipital tuberosity.

3. The relation of the areas of the cranium and face change with age. If the measurements obtained by Colin on the Lamb and Ram are compared, it will be perceived that the face grows as the creature ages. This change is very evident if the development of the young Hare is watched. At birth the face is very short—like that of a common dog, it is said; but when development is completed, we know how much the face has become lengthened.

4. Finally, in consulting the table of angles drawn up by Colin, we might believe that the facial angle widens as the animal advances in age. Thus, in the young Hinny, Colin estimated the facial angle at 15°; this angle was 16° on an

Fig. 53.



A, B, C, D. 1, Fronto-parietal crests; 2, external occipital tuberosity; 3, 3, superior root of the zygomatic process of the temporal bone.

old Hinny, and 17° on another very old one. In every instance, however, according to the same table, this angle will be equal in a four-years-old Horse and in an adult Horse; and even in the Calf it diminishes one degree when it becomes an adult animal.

The measurements we have taken in domestic Solipeds, have demonstrated that the facial angle diminishes in a constant manner as the animal grows old. Thus, this angle is 16° in an Ass three years old; it is 15° in the adult, and 12° in the very old Ass. We have found it 13° in a Foal of two years, and 11° in an old Horse; 15° in a Mule of eighteen months, and 12·30° in a very aged Mule.

This question has, therefore, to be again examined; and, however it may be decided, it will be seen, by what has been stated, that age induces very interesting changes in the form and proportions of various parts of the head.

If the crania of different breeds of Dogs are compared, there will be found very marked diversities in the prominence of the parietal convexity, and the development and distance apart of the fronto-parietal crests. A mere glance at the figures above (Fig. 53), will afford evidence of this.

On the cranium of the Mastiff (A), the parietal bulgings are little marked; the parietal crests are very elevated, and join each other early, so that the temporal muscles are in contact throughout the greater part of their inner margin. In the little Lap-dog (D), the parietal crests are widely separated from one another, and the cranium is so very convex as to resemble that of a Monkey. Between these extremes are many intermediates (B, C); and it would appear that the development of intelligence in the Dog results in rendering the parietal bones more convex, and the temporal fossæ narrower.

Comparison of the Head of Man with that of the Domesticated Animals.

1. *Occipital bone.*—The occipital of *Man* is large, flat, incurvated like a shell, and the external tuberosity is slightly developed, and united by a ridge to the occipital foramen, which is relatively very wide. Two series of ridges arise from the external tuberosity and pass towards the circumference of the bone; these are the superior and inferior curved or semicircular lines. There is an anterior and a posterior condyloid fossa pierced by a foramen at the bottom; and the jugular eminences, wide and slightly prominent, replace the styloid processes of the domesticated animals.

Fig. 54.

FRONT VIEW OF THE HUMAN CRANIUM.

1, Frontal bone; 2, nasal tuberosity; 3, supra-orbital ridge; 4, optic foramen; 5, sphenoidal fissure; 6, spheno-maxillary fissure; 7, lachrymal fossa; 8, opening of the nose divided by the vomer; 9, infra-orbital foramen; 10, malar bone; 11, symphysis of the lower jaw; 12, mental foramen; 13, ramus of the lower jaw; 14, parietal bone; 15, coronal suture; 16, temporal bone; 17, squamous suture; 18, upper part of the great ala of the sphenoid bone; 19, commencement of the temporal ridge; 20, zygoma of the temporal bone concurring to form the temporal arch; 21, mastoid process.

The internal face of the occipital of Man corresponds with the cerebrum and cerebellum; and for this purpose it shows four fossæ, distinguished into superior or cerebral, and inferior or cerebellar. These fossæ are separated by a crucial projection whose most developed portion forms the internal occipital protuberance.

The union of the occipital with the parietal bones, constitutes the lambdoidal suture. At the point where this bone meets the parietal and the squamous portion of the temporal, is found, in the infant, the lateral posterior fontanel.

2. *Parietal bones.*—The parietals are always isolated in early life, and sometimes consolidated with each other at the adult age. They are very large, quadrilateral, and occupy the summit and sides of the cranium.

The parietal crests are absent, but are replaced, in certain individuals, by two faintly marked curved lines situated a little above the inferior border of the bone. The middle portion of the external face is very convex.

On the internal face there is no parietal protuberance, but in its stead the internal occipital tuberosity. It also exhibits ramous channels, which in disposition are analogous to the ribs of a fig-leaf; as well as the parietal fossa, which corresponds to the parietal eminence.

3. *Frontal bone.*—The frontal bone of Man forms the upper part of the face and the anterior portion of the cranium. Convex from behind forward, then vertical in its upper three-fourths, the bone suddenly bends at the orbits, so as to become horizontal in its lower fourth.

The external face offers, above the forehead, two lateral frontal eminences, and above the nose, a middle frontal boss. To the right and left of the latter are two salient arches—the supra-orbital ridges. The internal face entirely belongs to the cranial cavity. It offers, on the median line, the saggital groove terminated by a frontal crest; and on each side of this line the frontal fossæ, corresponding to the eminences of that name, and orbital bosses to match the orbital roofs. There is no mortise for the articulation of the sphenoid bone.

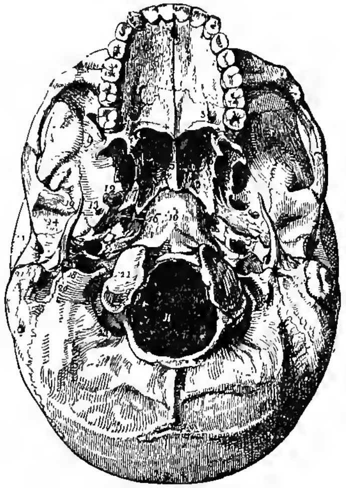
On the middle portion of the superior frontal border, in young persons, is the anterior angle of the anterior fontanel. The anterior border exhibits three supra-orbital foramina and the orbital arches.

4. *Ethmoid bone.*—In Man, the external face of the lateral masses—formed by a very thin lamina, termed the *os planum* or *lamina papyracæ*—belongs to the internal wall of the orbit.

5. *Sphenoid bone.*—This is distinguished, in Man, into a body and four wings—two large and two small.

The inferior surface of the body offers nothing remarkable, except the presence of a conical prolongation named the beak (*rostrum*) of the sphenoid. The external face of the greater wings forms part of the temporal fossa, as also the external wall of the orbit. At the union, of the wings with the body, are detached two bifid pterygoid processes; their internal branch represents the pterygoid bones of animals. There is no sub-sphenoidal canal.

Fig. 55.



EXTERNAL OR BASILAR SURFACE OF THE BASE OF THE HUMAN SKULL.

1, 1, The bony palate; 2, incisive, or anterior palatine foramen; 3, palatine process of palate bone, with the posterior palatine foramen; 4, palate spine with transverse ridge; 5, vomer; 6, internal pterygoid palate; 7, scaphoid fossa; 8, external pterygoid plate, with fossa; 9, zygomatic fossa; 10, basilar process of occipital bone; 11, foramen magnum; 14, glenoid fossa; 15, meatus auditorius externus; 16, foramen lacerum anterius; 17, carotid foramen of left side; 18, foramen lacerum posterius, or jugular foramen; 19, styloid process; 20, stylo-mastoid foramen, with jugular tubercle and digastric fossa; 21, mastoid process; 22, occipital bone; 23, posterior condyloid fossa.

The two lesser wings are very thin and triangular, and visible only on the superior surface of the bone; they constitute the processes of Ingrassias.

On the internal face of the bone are found: (1) a deep pituitary fossa, limited by four clinoid processes; (2) an optic fossa, shallow, showing very short optic canals transformed into foramina; (3) the sphenoidal fissure, which replaces the great supersphenoidal canal in the Horse; (4) the great foramen rotundum; (5) the internal face of the wings, much excavated; (6) the foramen ovale, which transmits the inferior maxillary nerve; (7) the small foramen rotundum that lodges the spheno-spinous artery.

6. *Temporal bone.*—In the squamous portion of the temporal bone of Man, the zygomatic process only rests on the malar bone, as in Ruminants. The glenoid cavity is concave in every sense, and divided into two parts by an opening named the *fissura Glaseri;* the anterior portion only is articular—the posterior, lying against the external auditory canal, does not belong to the articulation; it corresponds to the supra-condyloid eminence of the Horse. The tuberous portion is consolidated with the squamous. It is divided into a mastoid and a pyramidal portion; the latter comprises, in its turn, the petrous and tympanic portions. The mastoid portions correspond to the mastoid process, mastoid protuberance, and superior border of the petrous bone in the Horse. It presents a rugged mastoid process. Above this is the mastoid canal; and above and behind it, the digastric groove—the pyramid forming a considerable projection in the interior of the cranium. The styloid process or bone is altogether separate from the other pieces of the hyoid, and in the adult is consolidated with the temporal bone.

7. *Supermaxilla.*—In Man the premaxilla is no longer found independent, the centre which forms it coalescing with the supermaxillary bone.

The supermaxilla of man concurs, for the greater part of its extent, to form the floor of the orbit; it is also divided into three faces: an external or facial, a superior or orbital, and an internal or naso-palatine. The external face presents, from before to behind: (1) a small fossa, into which is inserted the myrtiform muscle; (2) the infra-orbital, or canine fossa, showing the inferior orifice of the infra-orbital canal; (3) a crest corresponding to the maxillary spine of Solipeds; (4) the alveolar tuberosity. This face carries, in front, a prolongation that forms the ascending process, also named, because of its relation, the fronto-nasal process. The superior or orbital face offers a fissure which precedes the infra-orbital canal, and, outwards, the malar process. The internal face is divided by the palatine process. It shows, in front, the half of the anterior nasal spine and a groove which participates in the formation of the incisive canal.

8. *Palatine bone.*—The palatine bone of Man is formed of two osseous laminæ—one horizontal, the other vertical—which are joined at a right angle. The first part presents: one-half of the

posterior nasal spine, which is altogether rudimentary, or even null in animals; the orifice of the posterior palatine canal, which belongs entirely to the palate bone; the pterygo-palatine foramen; lastly, the pterygoid process, which represents the pterygoid bone of animals. The vertical portion forms the external wall of the nasal cavities by its internal face, and by its external face concurs in the formation of the zygomatic or temporal fossa.

9. *Malar bone.*—This offers three faces. The external, or cutaneous, serves as a base for the most salient part of the cheek. The superior, or orbital, forms part of the external wall and floor of the orbit; it belongs to a long apophysis—the *orbital process*—which rests on the sphenoid and frontal bones. The posterior face is smooth and concave behind, where it aids to form the temporal fossa; in front it is uneven, and articulates with the supermaxilla. The posterior, or masseteric border, unites with the zygomatic process of the temporal bone.

10. *Lachrymal bone.*—This bone is also called the *os unguis* in Man, because of its likeness to the nail in shape and tenuity. It is entirely lodged in the orbit, and its external face is divided into two portions by a vertical crest; the portion situated in front of this crest forms part of the lachrymal groove. By its internal face, the lachrymal bone limits, outwardly, the bottom of the nasal cavities, and covers the anterior cells of the ethmoid; by its posterior border, within the orbit, it articulates with the os planum of the ethmoid.

11. *Nasal bone.*—The proper bones of the nose of Man exhibit a great analogy to those of the Dog. They do not possess a nasal prolongation, and they articulate with the lateral cartilage of the nose.

12. *Vomer.*—The same general form and relations as in Solipeds.

13. *Inferior maxillary bone.*—This bone in Man is in shape somewhat like a horse-shoe. It is nearly of the same width throughout its whole extent. The symphysis is vertical—a character peculiar to Man. Below this symphysis is a triangular projection—the mental eminence. The genial surface of the Horse is replaced by four little tubercles, termed the genial processes. The alveoli of the molar teeth form a great projection on the inner face of the bone. The mylo-hyoid ridge is very developed. The superior orifice of the dental canal is covered by a little sharp lamina. From this orifice begins the mylo-hyoidean groove. The coronoid process is short; the condyle is bent towards the median line, and the sigmoid notch is wide and shallow. The superior border contains fourteen or sixteen alveoli.

Article III.—The Thorax.

The *thorax* represents a coinoid cage, elongated from before to behind, suspended under the vertebræ of the dorsal region, and contains the principal organs of respiration and circulation. It is composed of bony arches named *ribs*, thirty-six in number—eighteen on each side—and a single piece—the *sternum*, which serves for the direct or indirect support of the inferior extremities of the ribs.

The Bones of the Thorax in particular.

1. Sternum of the Horse (Hæmal Spine) (Fig. 56).

This is an osteo-cartilaginous body, elongated from before backwards, flattened on each side in two-thirds of its anterior extent, and above and below in its posterior third; it is slightly curved on itself, and situated beneath the thorax in an oblique direction downwards and backwards. It offers for study, a *superior face*, *two lateral faces*, *three borders*, and *two extremities*.

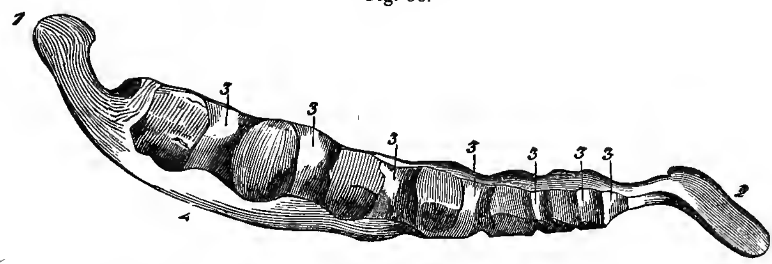
Faces.—The *superior face*, slightly concave longitudinally, represents an isoscelated lengthened triangle, the summit of which is directed forwards; it constitutes the floor of the thoracic cavity. The *inferior face* is shaped like the keel of a ship, having in its middle a longitudinal ridge, which decreases in height from before to behind. It has two inclined planes placed towards each other, each of which has two parts—a *superior* and an *inferior*. The first shows eight diarthrodial cavities, which receive the inferior extremity of the cartilages of the true ribs. These cavities are elongated vertically, and draw closer to each other as they extend backwards. The inferior part, which is more extensive before than behind, offers to the powerful pectoral muscles a large surface for insertion.

Borders.—The *two inferior borders* separate the superior from the inferior faces; they are situated above the diarthrodial cavities, are united anteriorly, and each gives attachment to a fibrous band.

Extremities.—The *anterior*, flattened on each side and curved upwards, exceeds to some extent the first articular cavity of the lateral faces, and in this way constitutes the *cervical prolongation* (*præsternum*) of the sternum. The *posterior* extremity is flattened superiorly and inferiorly, and forms a large cartilaginous plate, very thin, concave above, convex below, which has received the name of the *abdominal prolongation* (*ensiform cartilage*), or *xiphoid appendage.*

Structure and development.—The sternum is one of the parts of the skeleton

Fig. 56.



THE STERNUM.

1, The cervical prolongation (*præsternum*, or cariniform cartilage); 2, the xiphoid appendage (or *ensiform cartilage*); 3, 3, cavities for the articulation of the sternal cartilages; 4, inferior border.

which do not undergo complete osseous transformation. It is developed, in Solipeds, from six single nuclei of spongy substance, ranged one behind the other, like beads on a string. These nuclei never coalesce to form a solid piece, but remain separated during the life of the animal, by the primary cartilaginous mass. The latter constitutes the entire anterior prolongation of the bone and its carina, as well as the xiphoid appendage. When these parts of the sternum become ossified—which is rare—they are only partially so.

Differential Characters in the Sternum of other Animals.

In all the domesticated animals except Solipeds, the sternum is flattened above and below instead of on both sides.

A. **Ruminants.**—In Ruminants, each piece is developed from two lateral centres of ossification. The bones which compose it are seven in number; they are much more compact than those in the sternum of the horse, and at an early period are united to each other, with the exception of the first, which is joined to the second by a diarthrodial articulation that permits it to execute lateral movements. There is no cervical prolongation, and the xiphoid cartilage is feebly developed and well detached from the body of the bone. In the sternum of the *Goat* and *Sheep*, the two first pieces have no diarthrodial joint, but are simply united by a layer of cartilage, which, in old animals, becomes completely ossified. The sternum of the *Camel* has a very oblique direction downwards and backwards, and is formed by seven pieces; the first is somewhat rudimentary, while the two are very strong, and serve as a base for the sternal callosity or pad.

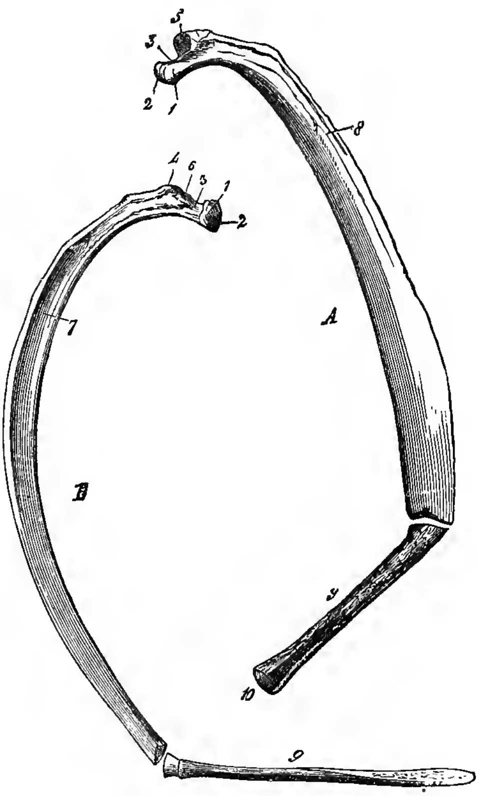
B. **Pig.**—The sternum of this animal presents in its general conformation the essential features of that of large Ruminants. It is provided with a well-defined cervical prolongation, and is composed of six pieces, which, at least in the four or five last, are each divided into two lateral nuclei.

C. **Carnivora.**—The sternum of the *Dog* and *Cat* is formed of eight pieces, elongated from before to behind, hollowed in their middle part, and thick at their ends—formed, indeed, like the last coccygeal vertebræ of the Horse. They are never ossified to each other.

2. The Ribs (Pleuropophyses) (Fig. 57).

As has been already remarked, on each side of the thorax there are eighteen ribs. These are nearly parallel to each other, and separated by the intervals termed the *intercostal spaces.* Attached by their superior extremity to the vertebræ of the dorsal region, these bones terminate at their inferior extremity by an elastic and flexible prolongation, named the *costal cartilage*, by means of which they are brought into direct or indirect relations with the sternum. The characters common to all the ribs will be first noticed, then the special features which serve to distinguish them from each other, and, lastly, the differences they exhibit in other than Soliped animals.

Fig. 57.



TYPICAL RIBS OF THE HORSE.

A, Inner face of the fifth sternal rib. B, External face of the first asternal rib. 1, Head of the rib; 2, its fissure; 3, neck; 4, tuberosity; 5, articular facet; 6, scabrous fossa for the insertion of the interosseous costo-transverse ligament; 7, groove on the external face; 8, vasculo-nervous groove on the posterior border; 9, prolonging cartilage; 10, A, articular tuberosity for union with the sternum.

A. Characters common to all the Ribs.—These will be studied from a typical point of view, first in the rib itself, and then in its cartilage.

1. *Description of a typical rib.*—A rib is an elongated asymmetrical bone, oblique from above to below, and from before to behind, flattened on both sides, curved like a bow, and twisted on itself in such a fashion that its two extremities cannot rest on the same horizontal plane. It is divided into a *middle portion* or *body*, and *two extremities.*

Middle portion.—This offers two faces and two borders. The external face is convex, and hollowed by a wide groove in its anterior half; it shows superiorly, towards the point corresponding to the angle of the rib in Man, some tubercles and muscular imprints. The internal face is concave and smooth, and covered by the pleura, which separates it from the lungs. The anterior border is concave, thin, and sharp; the posterior—convex, thick, and covered with rugged eminences—is channeled inwardly by a vasculo-nervous groove, which disappears near the middle of the rib.

Extremities.—The superior has two eminences—a *head* (*capitulum*) and a *tuberosity* (*tuberculum*)—which serve for the support of the rib against the spine.

The first is formed by two articular demi-facets, placed one before the other, and separated by a groove for ligamentous insertion ; it is isolated from the tuberosity by a narrow part, named the *neck*, which exhibits a rugged fossa for the implantation of a ligament. The second—situated behind the head, and smaller than it—is provided with imprints on its margin, and presents an almost flat diarthrodial facet at the summit. Each rib articulates by its head and tuberosity with two dorsal vertebræ ; the head is received into the intervertebral articular cavity ; the tuberosity corresponds, by its facet, to the transverse process of the posterior vertebra.

The inferior extremity is tuberous and excavated by a shallow cavity, irregular at the bottom, for the reception of the upper end of the costal cartilage.

Structure and development.—The ribs are very spongy bones, especially in their inferior moiety, and are developed at a very early period from three centres of ossification—a principal for the middle portion and inferior extremity, and two complementary for the head and tuberosity.

2. *Description of a typical costal cartilage.*—The costal cartilage (*hæmapophysis*) very evidently represents the inferior rib in Birds ; it is a cylindrical piece, slightly compressed at the sides, and round and smooth on its faces and borders. By its superior extremity, it is united to the rib it serves to lengthen, and forms with it an angle more or less obtuse, opening in front. At its inferior extremity, it is terminated by an articular enlargement, or by a blunt point. In youth, the costal prolongations are entirely composed of cartilaginous matter, but they are soon invaded by ossification ; so that in the adult animal they are already transformed into a spongy substance, with large areolæ which remain during life surrounded by a thin layer of cartilage.

B. Specific Characters of the Ribs.—The ribs, like the vertebræ of each region of the spine, have received numerical designations of first, second, third, etc., computing them from before to behind (Fig. 5). Owing to the presence of an altogether essential characteristic, they are naturally divided into two great categories—the *sternal* or *true ribs*, and the *asternal* or *false ribs*. The *sternal ribs*, numbering eight—the first eight—have their cartilages terminated inferiorly by an articular enlargement, which corresponds to one of the lateral cavities of the sternum, and brings the true ribs into direct contact with this portion of the skeleton. The *asternal ribs*, ten in number, rest on each other—the last on the seventeenth, that on the sixteenth, and so on—by the inferior extremity of their cartilage, which ends in a blunt point. The cartilage of the first false rib is united somewhat closely to the last sternal rib, and it is through the medium of this that all the asternal ribs lie indirectly on the sternum.

If, however, the ribs are considered altogether, with regard to the differential characters presented by them in their length, width, and degree of incurvation, it will be noted : 1. That their length increases from the first to the ninth, and from this diminishes progressively to the last. 2. That the same progressive increase and decrease exists in the cartilages. 3. That they become gradually wider from the first to the sixth inclusive, and then contract by degrees until the eighteenth is reached : 4. That the curve described by each is shorter and more marked as the rib is situated more behind. It may be added, that the channel on the external face is less conspicuous in proportion as the rib is narrow.

The first rib, considered individually, is always distinguished by the absence of the groove on its outer surface, by the vasculo-nervous groove on its posterior border, and the groove or notch intermediate to the two facets of its articular head. It is also recognized by the deep muscular imprints on its external face, the shortness and thickness of its cartilage, and particularly by the articular facet which this cartilage exhibits inwardly, to correspond to that of the opposite rib. The last rib has no channel on its external surface, and the facet of its tuberosity is confounded with the posterior facet of the head. This last character is also nearly always remarked in the seventeenth rib, and sometimes even in the sixteenth.

In the **Ass**, the ribs in general, but particularly those most posterior, are less curved than in the Horse. They differ more particularly in the curve of the neck being much shorter—a difference which is most obvious when the goniometer is applied to the angle of the rib, and the most salient part of the head and tuberosity. By this means we have obtained an angle the value of which was greater in the *Ass* than in the *Horse*: from 78° to 130° for the external ribs, and from 100° to 132° for the asternal ribs, of the first; from 60° to 125° for the sternal, and from 140° to 150° for the asternals, of the second. The upper extremity of the sternal ribs in the Ass is less twisted outwards than the same part in the Horse; and in the latter, the plane which passes by the head of the rib is more distant than the plane which, in the Ass, passes across the tubercle.

The ribs of the **Mule** are intermediate between those of the Ass and Horse, with regard to the value of the angle just indicated; they approach those of the Ass by the twist in their superior extremity.

Differential Characters in the Ribs of other Animals.

The number of ribs varies like that of the dorsal vertebræ. The following table indicate the number of these bones in the different domesticated animals:—

Pig	14
Ox	13
Sheep	13
Goat	13
Dog	13
Camel	12
Rabbit	12

A. **Ruminants.**—These animals, with the exception of the Camel, have eight sternal and five asternal ribs.

In the *Ox*, they are longer, wider, and less arched than in Solipeds. The articular eminences of the superior extremity are voluminous and well detached; the neck especially is very long. The sternal ribs are joined to their cartilage of prolongment by a real diarthrodial articulation. In the last rib, and sometimes in the one before it, the tuberosity is scarcely perceptible, and has no articular facet. In the *Sheep* and *Goat*, the sternal ribs are consolidated with the cartilages (Figs. 6, 7).

The *Camel* has eight sternal and four asternal ribs. The ribs increase in length to the tenth, and in width to the sixth only. They are less curved and are shorter, proportionately, than those of the Ox, the shortness being very marked in the first three. The tubercle is less detached than in the Ox, but the neck is longer and stronger (Fig. 8).

B. **Pig.**—In this animal there are fourteen pairs of ribs, seven of which are sternal and seven asternal. The first are provided with cartilages of prolongment flattened on both sides, extremely wide and sharp, and convex on their superior border. In the four last asternal ribs, the facet of their tuberosity is confounded with the posterior facet of the head (Fig. 3).

C. **Carnivora.**—They possess thirteen ribs on each side—nine sternal and four asternal. These are very much arched, narrow, and thick, and their cartilages rarely ossify. In the *Dog*, the articular facet of the tuberosity remains isolated from the posterior facet of the head in all the ribs. It is absent in the three last ribs of the *Cat* (Fig. 2).

The Thorax in General.

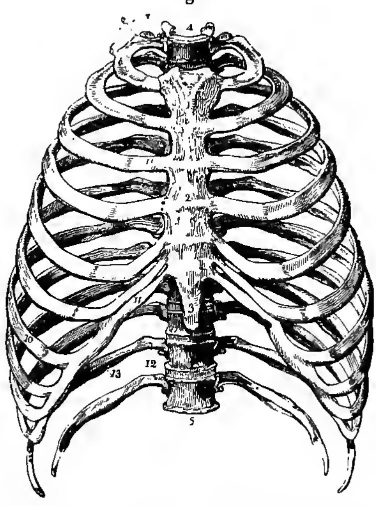
The description of the interior of the thoracic cavity will be referred to when treating of the respiratory apparatus. It is only necessary here to examine the external surface of this bony cage. For this purpose it is divided into six regions—*a superior plane, an inferior plane, two lateral planes, a base*, and *a summit*.

Planes.—The *superior plane* is separated into two portions by the spinous processes of the dorsal vertebræ; each forms, with these spinous processes, the *costo-vertebral* furrow, intended to lodge the majority of the muscles belonging to the spinal region of the back and loins. The *inferior plane*, less extensive than the preceding, offers: 1. On the median line, the cariniform and xiphoid cartilages of the sternum; 2. On the sides, the chondro-sternal articulatious, and the cartilages of prolongment of the true ribs. The *lateral planes* are convex and wider at their middle part than in front or behind, and exhibit the intercostal spaces. They serve to give support, anteriorly, to the superior segments of the two anterior limbs.

Base.—This is circumscribed by the posterior border of the last rib, and by the cartilages of all the asternal ribs; it is cut obliquely downwards and forwards, and gives attachment, by its internal circumference, to the diaphragm—a muscle which separates the thoracic from the abdominal cavity.

Summit.—It occupies the anterior portion of the thorax, and presents an oval opening, elongated vertically, situated between the two first ribs. This opening constitutes the entrance to the chest, and gives admission to the trachea, the œsophagus, and important vessels and nerves.

Fig. 58.



THORAX OF MAN (ANTERIOR FACE).

1, Superior piece of the sternum; 2, middle piece, or body; 3, inferior piece, or ensiform cartilage; 4, first dorsal vertebra; 5, last dorsal vertebra; 6, first rib; 7, its head; 8, its neck, resting against the transverse process of the first dorsal vertebra; 9, its tubercle; 10, seventh, or last true rib; 11, costal cartilages of the true ribs; 12, the last two false or floating ribs; 13, the groove along the lower border of the rib.

Comparison of the Thorax of Man with that of the Domesticated Animals.

1. Sternum.

The sternum of Man is flattened before and behind, and diminishes in width from above to below. The xiphoid appendage is narrow, and single or bifid. Besides the articular surfaces for the ribs, there are found on the upper end two lateral notches for articulation with the clavicles.

2. Ribs.

Of the twelve ribs in Man, seven are sternals and five asternals. They are short, narrow, and much incurvated, especially the first ones. In each rib the curvature is more marked in the posterior fourth or fifth, than in the anterior three-fourths or four-fifths; this sudden change of curvature is indicated in the external face by a kind of inflection and thickening, called the angle of the ribs. The prolonging cartilages of the eleventh and twelfth ribs are short, and are lost in the substance of the abdominal parietes; for this reason they are termed the *floating* (or *false*) *ribs* (Fig. 58).

Article IV.—Anterior Limbs.

The *anterior* (*pectoral* or *thoracic*) limb is divided into four secondary regions—the shoulder, arm, forearm, and fore foot or hand.

SHOULDER.

In Solipeds, this region has for its base a single bone—the *scapula* or *omoplat.*

SCAPULA (Figs. 59, 60).

This is a flat, triangular, and asymmetrical bone, prolonged at its superior border by a flexible cartilage, articulated inferiorly with the humerus only, and applied against the lateral plane of the thorax in an oblique direction downwards and forwards. It has *two faces*, *three borders*, and *three angles.*

Faces.—The *external face* (or *dorsum*) is divided by the *scapular* or *acromian spine*, into two cavities of unequal width—the *supra-* and *infra-spinous* (or *antea* and *postea spinatus*) *fossæ.* The *spine* is a very salient crest which runs the whole length of the external scapular surface ; very elevated in its middle part, which shows an irregular enlargement—the *tuberosity* of the spine—it insensibly decreases towards its two extremities. The *supra-spinous fossa*—the narrowest—is situated above, or rather in front of the spine ; it is regularly concave from side to side, and perfectly smooth. *The infra-spinous fossa* is twice the width of the preceding, and occupies all the surface behind the spine. It exhibits : 1. Below, and near the posterior border, several rows of roughened lines for muscular insertion. 2. Near the neck, the nutritient foramen of the bone, and some vascular grooves.

The *internal face* is excavated in its centre to form a hollow, called the *subscapular fossa*, which is prolonged superiorly by three diverging points. The median point extends to the superior border of the bone, and separates two roughened triangular surfaces.

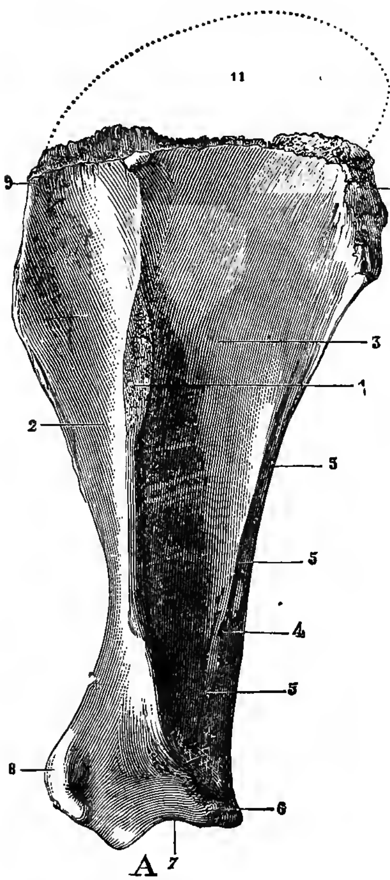
Borders.—The *superior* is indented by an irregular groove, to receive the inferior margin of the *cartilage of prolongation.* The latter is convex on its superior border, extends beyond the posterior angle of the bone, and gradually diminishes in thickness as it leaves its point of attachment. In old horses it is nearly always found partially ossified. The *anterior border*, thin and sharp, is convex in its superior two-thirds, and slightly concave for the remainder of its extent. The *posterior* is thicker and a little concave.

Angles.—The *anterior*, or *cervical angle*, is the thinnest of the three. The *posterior* or *dorsal angle* is thick and tuberous. The *inferior*, or *humeral angle*, is the most voluminous, and is separated from the remainder of the bone by a slight constriction, which constitutes the *neck* of the scapula. It exhibits : 1. The *glenoid cavity*—an oval diarthrodial surface, excavated to a slight extent to receive the head of the humerus, notched on the inner side, and bearing on the external margin of the ridge which surrounds it a small tubercle of insertion. 2. The *coracoid process*, situated in front, and at a certain distance from the glenoid cavity. This is a large eminence in which may be distinguished two parts : the *base*, a thick rugged process ; and the *summit*, a kind of beak curved inwards.

Structure and development.—Like all the flat bones, the scapula is formed of two compact layers separated by spongy tissue. The latter is very scanty towards the middle of the supra- and infra-spinous fossæ, where it is often altogether wanting ; it is most abundant in the angles. In Solipeds and Ruminants, the scapula is developed from two principal centres of ossification, one of which forms the coracoid process.

In the Carnivora, the cartilage of prolongation is replaced by an epiphysary lip. It may be added that in Mammalia, Meckel, Cuvier, and Strauss-Durckheim have noted a supplementary nucleus in the glenoid cavity ; and that Lavocat and Goubaux have observed it in Horses especially. Lavocat has described it as a pyramidal nucleus, base inferior, and flattened before and behind. In the Horse, it appears at the centre of the cavity towards the seventh or eighth month; it increases and pushes forward the coracoid process beyond the articular surface. In about nine or ten months it is fused with the principal part of the bone, and in about a year with the coracoid nucleus. In the Ass and Mule, the *glenoid*

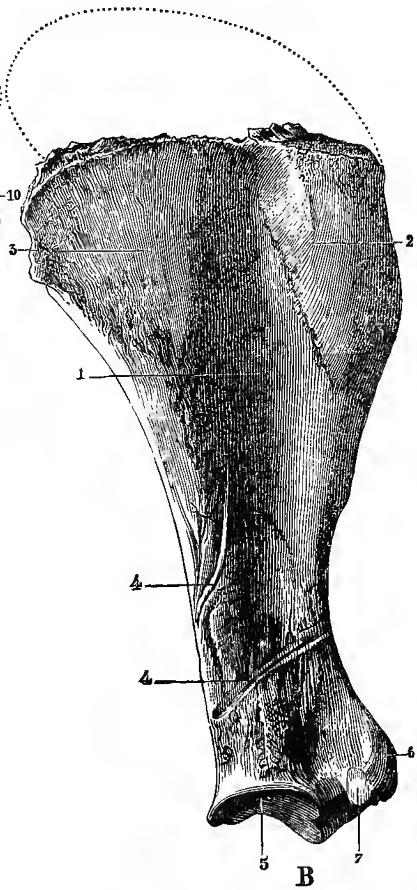
Fig. 59.



SCAPULA OF THE HORSE (EXTERNAL FACE).

1, Tuberosity of the spine; 2, supra-spinous fossa; 3, infra-spinous fossa; 4, nutrient foramen; 5, 5, 5, linear imprints for the insertion of the coraco-humeralis; 6, tubercle for the same; 7, border of the glenoid cavity; 8, coracoid process; 9, cervical angle; 10, dorsal angle; 11, cartilage of prolongation.

Fig. 60.



1, Subscapular fossa; 2, anterior triangular surface; 3, posterior triangular surface; 4, 4, vascular furrow; 5, glenoid cavity; 6, base of the coracoid process (insertion of the coraco-humeralis).

nucleus appears about the fourth month, and its evolution is completed at the seventh or eighth month.

In the **Ass**, the scapula is usually more curved than in the Horse, while the greater development of its superior border, and the more considerable constriction of its neck, give it a peculiar appearance. It represents a wider and shorter triangle than in the Horse, and the spine gradually decreases from the tuberosity until it is nearly lost on the surface of the bone, towards the nutrient foramen. In the Horse, this subsidence of the spine occurs at the neck, where it takes place quite suddenly; so that it forms a more or less marked prominence.

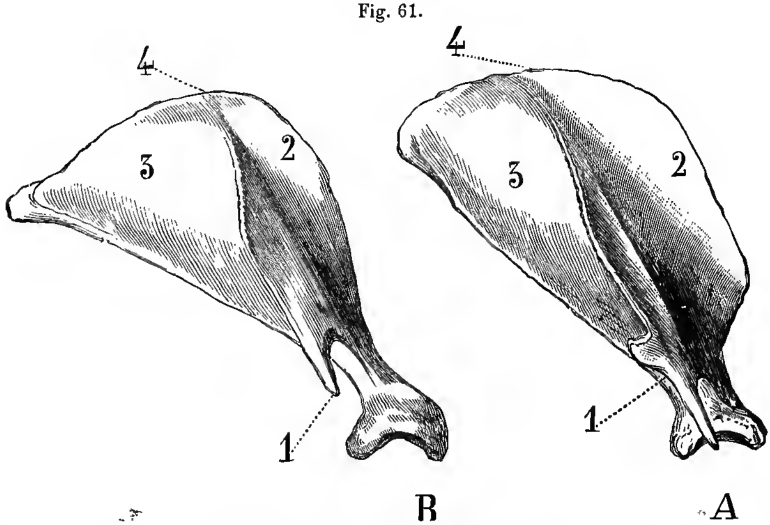
The scapula of the **Hinny** has the general form of that of the Ass; in the Mule, on the contrary, it is elongated like that of the Horse.

Differential Characters in the Scapula of other Animals.

The shoulder is composed of one or two bones, according as the limb is intended exclusively to support the body, or is required for other purposes.

A. **Ox, Sheep, Goat.**—In these animals the shoulder comprises only one bone—the scapula—which is more regularly triangular than in the Horse. The spine does not diminish in passing to the neck, but, on the contrary, terminates at a certain distance above the glenoid

Fig. 61.



SCAPULA OF THE CAT AND RABBIT.

A, Scapula of the Cat. B, Scapula of the Rabbit. 1, Inferior extremity of the acromian spine; 2, supra-spinous fossa; 3, infra-spinous process; 4, superior border.

cavity by an abrupt ridge prolonged to a point, which represents a rudimentary *acromion process*. It divides the external surface of the bone into two fossæ, which in extent are as I:3. The neck is more constricted, and the humeral angle better detached, than in Solipeds.

B. **Camel.**—The scapula of this animal resembles that of the Ox in its general form, but the spine divides the face into two equal fossæ. The acromion process descends to the glenoid cavity.

C. **Pig.**—The spine, depressed at its two extremities, rises considerably at its middle portion, and bends over towards the infra-spinous process.

D. **Carnivora.**—Their shoulde[illegible] is two bones—the scapula and clavicle. In the *Dog*, the latter is li[illegible] more than a shell embedded in the muscles in front of the scapulo-humeral angle; in th[illegible] constitutes a small styloid bone which is united to the acromion process and the ster[illegible] the medium of two ligaments. The scapula has no cartilage of prolongation [illegible] is very convex, as if it had been curved over on itself. The fossæ of the ex[illegible] the spine terminates in an acromion process that reaches the glenoid [illegible]

E. [illegible] [illegible]ulder of this animal. The clavicle, although longer than that o[illegible] [illegible]st directly on the sternum and scapula. The latter is in shap[illegible] is slender; the fossæ on the external face are very unequal: [illegible] acromion pedicle to the vicinity of the glenoid cavity; and the s[illegible] [illegible]ded with a cartilage of prolongation.

Arm.

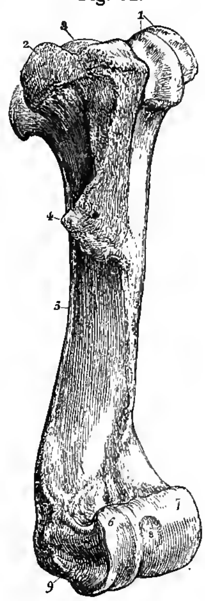
This region has only one bone, the *humerus*.

Humerus (Figs. 62, 63).

The *humerus* is a long single bone, situated between the scapula and the bone of the forearm, in an oblique direction downwards and backwards. Like all the long bones, it offers for study a *body* and *two extremities*.

Body.—The body of the humerus looks as if it had been twisted on itself from within to without in its superior extremity, and from without to within at the opposite end. It is irregularly prismatic, and is divided into *four faces*. The *anterior face* (Fig. 62), wider above than below, has in its middle and inferior portions some muscular imprints. The *posterior*, smooth and rounded from one side to the other, becomes insensibly confounded with the neighbouring faces. The *external* is excavated by a wide furrow, which entirely occupies it, and turns round the bone obliquely from above to below and behind to before; it is to the presence of this channel that the humerus owes its apparent twist, and it is in consequence designated the *furrow of torsion* (or *musculo-spiral groove*) of the body of the humerus.

Fig. 62.



ANTERO-EXTERNAL VIEW OF RIGHT HUMERUS.

1, Trochlear or bicipital ridges; 2, external or deltoid tuberosity; 3, head or articular surface; 4, external tubercle; 5, shaft or body with its twisted furrow; 6, 7, articular or trochlear condyles; 8, ulnar fossa with a sulcus; 9, fossa for the insertion of the external lateral ligament.

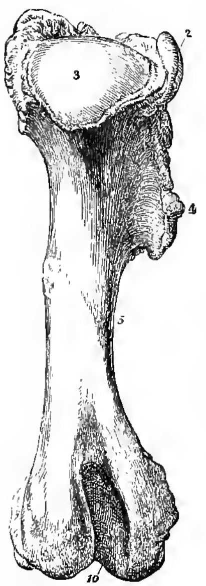
This furrow is separated from the anterior face by a salient border—the *deltoid ridge*, which ends inferiorly above the coronoid fossa, and superiorly, towards the upper third of the bone, by the *imprint*, or *deltoid* (or *external*) *tuberosity*. This is a roughened, very prominent eminence, flattened before and behind, and inclining towards the furrow of torsion; by its superior extremity, it gives origin to a curved line which is carried backwards to join the base of the articular head. Near the inferior extremity, backwards and outwards, is seen the *posterior deltoid ridge*, which separates the latter from the posterior face of the bone. The *internal face* of the body of the humerus, rounded from side to side, is not separated from the anterior and posterior faces by any marked line of demarcation. It offers, near its middle, a depressed scabrous process (the *internal tuberosity*) for the insertion of the teres major and latissimus dorsi muscles. Towards its inferior third it shows the nutrient f[illegible] bone.

Extremities.—These are disting[illegible] into *superior* and *inferior*. Both are slightly curved—the first backwards, the second forwards—a dispositi[illegible] which tends to give to the humerus the form of an S.

The *superior extremity* [illegible] [illegible]luminous, and has three thick eminences—a posterior, external, a[illegible] first constitutes the *head* of the humerus. It is a very slightl[illegible] eminence, rounded like the segment of a sphere, and cor[illegible] glenoid cavity of the scapula, which is too small to re[illegible] [illegible]e external eminence—named the *trochiter*, *large* (or *external*) *trochanter*, and *great tuberosity*—comprises three portions, named the *summit*, *convexity*, and *crest* of the great tuberosity. The internal eminence—the *trochin*, *little* (or *internal*) *trochanter*, or *small tuberosity*—also presents three distinct portions, which, by their position, correspond exactly with the three regions of the external trochanter ; these are so many muscular facets.

The external and internal trochanters are separated from each other in front by a channel called the *bicipital groove*, because the superior tendon of the biceps muscle glides over it. It consists of two vertical grooves, with a median ridge between them.

Fig. 63.



POSTERIOR VIEW OF THE RIGHT HUMERUS.

2, External trochanter; 3, articular head of the bone; 4, external tubercle and ridge; 5, body or shaft of the bone; 10, condyloid fossa.

The *inferior extremity* of the humerus has an articular surface corresponding with the radius and ulna. This surface—elongated transversely, convex from before backwards, and of greater extent within than without—exhibits two trochlea separated by an antero-posterior relief.

The *median* or *internal trochlea*, the deepest, is limited internally by a kind of voluminous condyle, which corresponds to the inner lip of the humeral trochlea of Man. The *external trochlea* is bordered outwardly by a slightly salient lip, which corresponds to the condyle of the humerus of Man. Above and behind this articular surface is a wide deep fossa—the *olecranian* (or *condyloid*), so named because it lodges the rostrom of the olecranon in the extension movements of the forearm. It is bordered by two eminences, the external of which is less elevated than the internal. The first represents the epitrochlea, and the second the epicondyle, of the humerus of Man. In front, and above the inner trochlea, there is another, but less spacious fossa, which receives the coronoid process during extreme flexion of the forearm, and which, for this reason, it would be convenient to designate as the *coronoid fossa*. Always in front, but above the external trochlea, are imprints for the attachment of the capsular ligament of the elbow-joint and the extensor metacarpi magnus. Lastly, at the extremities of the transverse axis of the inferior articular surface is remarked, outwardly, an excavation for ligamentous insertion; inwardly, a small tuberosity for the same purpose.

Structure and development.—The humerus, like all the long bones, is only spongy at its extremities. It is developed from six points of ossification, one of which alone forms the body, one the head and the internal trochanter, another the external trochanter, a fourth the inferior articular surface, a fifth the epicondyle, and the last for the epitrochlea. The latter is sometimes absent. In the young animal the humerus is less twisted, and the eminences for muscular insertion less developed, than in the adult.

In the **Ass**, the humerus is more twisted and curved in S form than in that of the Horse, and these modifications replace the eminences on this bone in the latter. Consequently, the equilibrium of the humerus is altered when it lies on a horizontal plane by any one of its faces and its lower extremity. Thus, while the humerus of the Ass may rest in equilibrium on a plane—its trochlea and two other points of its anterior face touching it—the Horse's humerus can only do so when the condyle, trochlea, and one or two points of its superior extremity touch it.

Laid on its posterior face, the humerus of the Ass is in unstable equilibrium, if it has to touch the plane by the epicondyle and epitrochlea; this is not so with the humerus of the Horse. If it is placed on its external side, the deltoid imprint remains above the horizontal plane with the Ass, and touches it with the Horse. Lastly, the epitrochlea descends nearly to the articular surface in the Ass, so that the bone is almost in equilibrium when it is placed on its inferior extremity.

The humerus of the **Mule** and **Hinny** resembles that of their parents, but that of the Hinny is more like the Ass's, and that of the Mule the Horse's.

Differential Characters in the Humerus of other Animals.

Proportionately, the humerus is longer, and more inflected like an S, as the number of apparent digits is increased. Therefore it is that, in the Carnivora, the characters of length and inflection are most marked.

A. **Ox, Sheep, Goat.**—In these animals, the furrow of torsion is less marked, and the deltoid imprint less salient than in the Horse, while the extremities are larger and more curved. The bicipital groove is divided into two depressions by a median ridge; the external trochanter is enormous, and its very elevated summit is bent over the bicipital groove. The head is better detached and the trochlea deeper than in the Horse. The medullary canal of the humerus of the Ox is sometimes crossed by an osseous band.

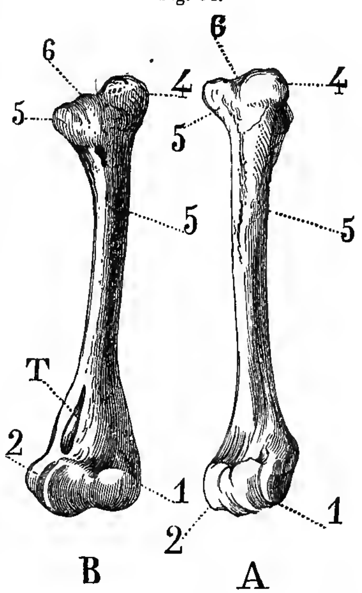
B. **Camel.**—Humerus cylindrical and nearly straight. Torsion furrow shallow; nutrient foramen on its anterior face. Bicipital groove double, the inner cavity being larger than the external. The inferior articular surface is relatively very narrow, and the external trochlea deep.

C. **Pig.**—The humerus of this animal is compressed on both sides; the head is much bent backwards, which increases its S inflection. A single bicipital groove placed within the superior extremity; the external trochanter voluminous, and the summit turned over the bicipital groove. Deltoid imprint and internal tuberosity of the body replaced by simple muscular imprints.

D. **Dog** and **Cat.**—The humerus is very elongated and more S-curved than in all the other animals, and the internal tuberosity is replaced by some imprints; while the bicipital groove is single, and the nutrient foramen, on the posterior face, is as in the Ox, Sheep, and Pig. The coronoid fossa communicates with that of the olecranon by a foramen.

E. **Rabbit.**—The humerus of this animal greatly resembles that of the Dog, except that it is much more flattened on each side, and the deltoid imprint is on the anterior face and nutrient foramen on the inner face of the bone.

Fig. 64.



HUMERUS OF THE CAT AND RABBIT.

A, Humerus of the Rabbit. B, Humerus of the Cat. 1, Condyle; 2, trochlea; 3, diaphysis; 4, external trochanter; 5, internal trochanter; 6, bicipital groove.

Forearm.

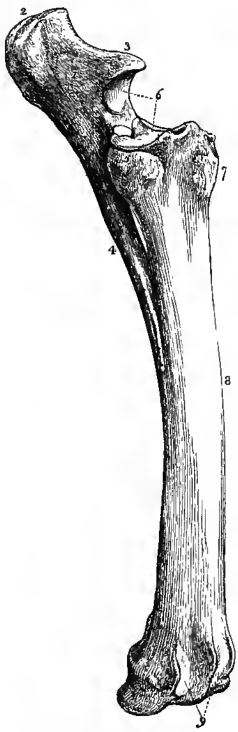
This region has for its base two bones—the *radius* and *cubitus* (or *ulna*), united into a single piece (*os antibrachii*) at an early period in most of the domesticated animals.

1. Radius (Figs. 65, 66).

This is a long bone, placed in a vertical direction between the humerus and the first row of carpal bones, and divided into a *body* and *two extremities*.

Body.—Slightly arched and flattened before and behind, it presents for study *two faces* and *two borders.* The *anterior face* is convex and perfectly smooth. The *posterior*, a little concave from one extremity to the other, offers : 1. Near the external border, a triangular surface, covered with asperities, elongated vertically, very narrow, commencing near the upper fourth of the bone, and terminating in a fine point towards the lower fourth ; this surface is brought into contact with the anterior face of the ulna by an interosseous ligament, which is completely ossified before the animal reaches adult age. 2. Above, there is a wide, transverse, but shallow groove, which aids in forming the radio-ulnar arch, and shows, near the point where it touches the preceding surface, the nutrient foramen of the bone. 3. Near the internal border, and towards the inferior third, there is a vertically elongated and slightly salient eminence for insertion. The *two borders—external* and *internal*—are thick and rounded ; they establish an insensible transition between the faces.

Fig. 65.



EXTERNAL FACE OF THE RADIUS AND ULNA.

1, Ulna; 2, point of the ulna; 3, beak of ulna or olecranon; 4, radio-ulnar arch; 5, supero-external tuberosity; 6, radio-ulnar articular surfaces for the humerus; 7, bicipital tub rosity; 8, shaft or body of the radius; 9, grooves for tendons.

Extremities.—The *superior* is larger than the inferior. It has : 1. An articular surface elongated from one side to the other, concave from before to behind, wider within than without, and moulded to the articular surface of the inferior extremity of the humerus ; there is also seen, outwardly, a double depression (*glenoid cavities*), which receives the two lips of the external trochlea ; in the middle, an antero-posterior ridge, which is received into the internal trochlea ; within, an oval cavity corresponding to the internal border of the former. 2. The *external tuberosity*, placed at the extremity of the great diameter of the articular surface ; it is prominent and well detached. 3. The *internal* or *bicipital tuberosity*—a large, very rugged, and depressed process, situated within and in front of the glenoid cavity. 4. A little lower, and on the same side, there is a strong muscular and ligamentous imprint, separated from the preceding tuberosity by a transverse groove intended for the passage of a tendon. 5. The *coronoid process*,[1] a small conical eminence, at the summit of which terminates, anteriorly, the median ridge of the articular surface. 6. Two diathrodial facets elongated transversely, cut on the posterior outline of the large articular surface, with which they are confounded by their superior border ; they correspond with similar facets on the ulna. 7. Below these, a roughened surface which extends to the radio-ulnar arch, and is in contact with an analogous surface of the same bone through the medium of an interosseous ligament. In the Horse, this ligament rarely becomes ossified.

The *inferior extremity*, flattened before and behind, presents : 1. Inferiorly, an articular surface elongated transversely and somewhat irregular, responding to the four bones in the upper row of the carpus. 2. On the sides, two tuberosities

[1] In Man this belongs to the ulna.

for ligamentous insertion—the *internal* salient and well circumscribed, the other *external*, and excavated by a vertical fissure—in which passes a tendon. 3. In front, three grooves for the gliding of tendons ; the external is the largest, and vertical like the median ; the internal, the narrowest, is oblique downwards and inwards. 4. Posteriorly, a strong transverse ridge which surmounts the articular surface, and serves for the insertion of ligaments.

Structure and development.—The radius is a very compact bone, and is developed from three centres of ossification—one for the body, and two for the extremities.

2. Ulna (Figs. 65, 66).

This is an elongated, asymmetrical bone, in the form of an inverted triangular pyramid, applied against the posterior face of the radius, to which it is united in adult Solipeds. It offers for description a *middle portion* and *two extremities.*

Middle portion.—This has *three faces* wider above than below, and *three borders* which become joined at the inferior extremity of the bone. The *external face* is smooth and nearly plane. The internal is also smooth and slightly hollowed. The *anterior* is formed to correspond with the radius, and presents peculiarities analogous to those of the posterior face of that bone. Thus, there is found, in proceeding from above to below : 1. Two small diarthrodial facets.[1] 2. A roughened surface. 3. A transverse groove for the formation of the radio-ulnar arch. 4. A triangular surface, studded with rugosities, which occupies the remainder of the bone to its lower extremity. The lateral borders—*external and internal*—are sharp, and, like the anterior face, are in contact with the radius. The *posterior border* is concave, rounded, and thicker than the other two.

Extremities.—The *superior extremity* comprises all that portion which exceeds the articular surface of the radius. It constitutes an enormous process—the *olecranon*—flattened on both sides, and presenting : 1. An external face, slightly convex. 2. An internal excavated face. 3. An anterior border, thin and sharp superiorly, notched below to form the *sigmoid cavity*[2]—an articular surface concave from above downwards, rounded from one side to the other, which corresponds with the humeral cavity, and is surmounted by a salient prolongation named the *beak of the olecranon.* 4. A concave and smooth posterior border. 5. The *summit*—a kind of thick roughened tuberosity which terminates the ulna above, and into which are inserted the extensor muscles of the forearm.

At its *inferior extremity*, the ulna ends, towards the lower fourth of the principal portion of the forearm, in an acute point, and sometimes by a small knob (*capitulum ulnæ*). It is not rare to see it prolonged, especially in the Ass and Mule, to the inferior external tuberosity of the radius. This tuberosity then appears to belong to it, at least in part ; and all that portion which is situated behind its vertical groove might be justly considered as a dependency of the ulna.

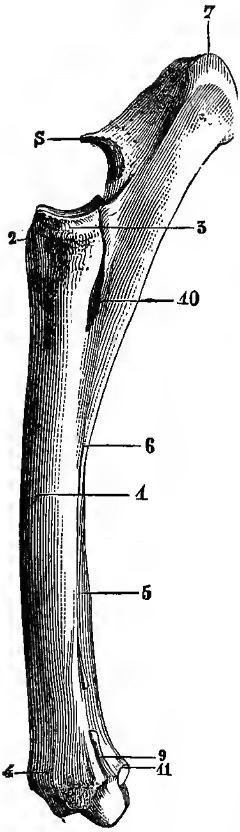
Structure and development.—The ulna contains much compact tissue, even in the region of the olecranon ; it is also very solid. It is an imperfect bone, developed from two centres of ossification only, one of these being for the apex of the olecranon.

In the **Ass** (Fig. 66), the radius is more curved than in the Horse, and when its anterior face is placed on a horizontal plane, the bone only rests on its upper

[1] The *smaller sigmoid cavity* of Man.
[2] The *greater sigmoid cavity* of Man.

end and the middle of the body. It is also distinguished from that of the Horse by the depth of a narrow groove, which passes through the rough lip above and behind the inferior surface, superior to the small fossa that receives the third bone of the upper row of the carpus during flexion and extension movements. The *ulna* of this animal is more developed than that of the Horse, and its olecranon is proportionately shorter, broader, and more hollowed on its internal face. The inferior extremity (Fig. 66, 9) is nearly always formed by a particular nucleus, which is also sometimes the case in the Horse.

Fig. 66.



FOREARM BONES OF THE ASS.

1, Diaphysis of the radius; 2, bicipital tuberosity; 3, external and superior tuberosity of the radius; 4, groove for the passage of the anterior extensor of the phalanges; 5, surface for insertion of branch of the perforans tendon; 6, body of the ulna interrupted at its lower third, but more complete than usual; 7, summit of the olecranon; 8, beak of ditto; 9, inferior extremity of ditto; 10, radio-ulnar arch; 11, crest above the inferior articular surface of the radius, behind.

In the **Hinny**, the bone of the forearm resembles that of the Ass, with the exception of the smallness of the lower end of the ulna.

Differential Characters in the Forearm Bones of other Animals.

The principal differential characters that they present are connected with the relative dimensions of the two bones and their mode of union. Regarding these, and as generally applicable, the following principles may be laid down :—

1. *The development of the ulna is in direct relation to the division of the foot.*—Monodactylous animals—such as the Horse, Ass, and Mule—have, in fact, only a rudimentary ulna. In the pentadactylous animals, on the contrary—as Man, the Cat, Elephant, etc.,—this is a veritable long bone which equals, or even exceeds, the radius in volume.

2. *The closeness of union between the radius and ulna is in increased proportion as the animal exclusively employs its inferior extremity for standing and walking.*—Thus, in Solipeds and Ruminants, and Pachyderms in general, the two bones are consolidated, or at least united by an interosseous ligament, and in so firm a manner that they can only execute very obscure movements on each other. The anterior limb of these animals is, indeed, only used to support the body on the ground. In those, on the contrary, which may employ it to dig up the soil, climb on trees, etc., or as an organ of prehension, the radius and ulna are merely joined at their extremities by an articulation, which permits them to move upon one another with the greatest facility. Rodents, the majority of the Carnivora, and the Quadrumana, are so provided; but it is in Man that the relative independence of the two bones is carried to the highest degree. No animal can so easily execute the movements of pronation and supination of the hand, which are determined by the play of the two bones of the forearm on each other.

To the indication of these fundamental characters, may be added some details on a few particular and important points.

A. **Ox, Sheep, Goat.**—The forearm of the *Ox* is short; that of the *Sheep* and *Goat* is longer; but in the three species, the ulna—thicker than in the Horse—is a long bone developed from three primary nuclei. It extends the whole length of the radius, and concurs in forming the articular surface corresponding with the carpal bones.

The inferior articular surface is cut obliquely downwards and inwards. There are two radio-ulnar arches—a superior and inferior—united externally by a deep fissure. The union of the two bones is more intimate than in the Horse; for ossification always ends by invading that portion of the interosseous ligament placed above the superior vascular arch (Fig. 71).

B. **Camel.**—The radius of this animal has a narrow, superior, articulating surface of two glenoid cavities, separated by a median salient crest terminating in front by a very marked coronoid process; the bicipital tuberosity is large, and on the anterior face. The ulna is very concave in its middle part, and the olecranon is broad and low.

C. **Pig.**—The radius is short, its inferior surface cut rather obliquely as in Ruminants, and partly formed by the inferior extremity of the ulna, which is a voluminous bone provided with a medullary canal, and solidly united to the radius by an interosseous ligament, the complete ossification of which is rare. It is flattened before and behind, and is spread over the posterior face of the radius, so as nearly to completely cover it. The olecranon is very prominent (Fig. 76).

D. **Dog, Cat.**—The two bones of the forearm are nearly equal in volume, and are in contact only by their extremities, where they show for this purpose: 1. Above, on the ulna, a concave articular surface—the *small sigmoid cavity;* and on the radius, a rounded hinge-like facet. 2. Below, two facets analogous to the preceding, but much smaller; that on the radius is concave, and that on the ulna convex. These two bones slightly cross each other, so that the upper end of the ulna touches the radius behind and inwards, while the inferior terminates altogether outwards. In the Pig and Ruminants, the lower end is in contact with the upper row of carpal bones (Fig. 77).

E. **Rabbit.**—The ulna is still more developed than in the Cat, and more curved lengthways.

The posterior border of the olecranon is almost vertical, instead of being oblique from before to behind, and the sigmoid notch is deeper and shorter curved than in the Carnivora.

ANTERIOR (OR FORE) FOOT, OR HAND.

The *anterior foot*, or *hand*, is the region which presents the greatest differences when it is examined in the various individuals of the animal series. Nevertheless, notwithstanding these varieties, its constitution is fundamentally the same, and may be divided into three sections—the *carpus*, *metacarpus*, and *phalangeal region.*

In vertebrate animals, the hand is composed of a certain number of parallel or quasi-parallel segments, which constitute the *digits.* Each complete digit is subdivided into three sections, placed one above the other; these are, reckoned from above to below—*carpus*, *metacarpus*, and *phalanges.*

The number of apparent digits varies from one to five; and, however it may otherwise appear, philosophical anatomy has shown that the hand of all the domesticated animals may be considered as belonging to the pentadactylous type. When it does not appear to be so, this is due to more or less numerous or extensive atrophies or abortions always occurring according to fixed laws. (See remarks hereafter on the Hand in General.)

1. Carpal Bones (Figs. 67, 68, 69).

The carpus (or *knee*) forms the base of the hand. Situated between the inferior extremity of the radius and the superior extremity of the metacarpal bones, it is composed of several small bones joined to each other, in the fresh state, by extremely solid articular bands. Collectively, they form an almost quadrilateral mass, in which may be distinguished two faces and four borders.

The *anterior face* is slightly convex from side to side, and irregular; it is in contact with the tendons of the extensor muscles of the metacarpus and phalanges.

The *posterior face* is very unequal, and converted—especially outwardly—into a groove, in which the tendons of the flexor muscles of the phalanges glide.

The *superior border* articulates with the radius ; the *inferior border* with the metacarpal bones.

The *lateral borders* are nearly flat ; above and behind the external border is remarked a considerable eminence, formed by the bone which will be hereafter studied as the supercarpal bone (pisiform or trapezium).

Fig. 67.

RIGHT ANTERIOR FOOT OR HAND OF A HORSE.

1, Radius; 2, grooves for the extensor of the phalanges; 3, scaphoid; 4, lunar; 5, cuneiform; 6, pisiform; 7, magnum; 8, unciform; 9, great metacarpal; 10, small metacarpal; 11, sesamoid bone; 12, suffraginis; 13, coronary; 14, navicular; 15, pedal; 16, basilar process.

In the carpus of the Horse are seven or eight bones, which are disposed in two superposed rows. The superior row comprises four bones placed side by side, and designated by the numerical names of *first*, *second*, *third*, and *fourth*, viewing them from without to within. The inferior row has only three, which are named in the same manner.

In applying to them the names proposed by Liser, we have, in the upper row—

1. The pisiform, or supercarpal bone.
2. The cuneiform bone.
3. The lunar bone.
4. The scaphoid bone.

In the inferior row—

1. The unciform bone.
2. The magnum bone.
3. The trapezoid bone.
4. The trapezium (not constant).

The description of these bones is most simple, and may be made in a general manner for all. Thus, with the exception of the supercarpal bone, they are solid, nearly cubical in form, and exhibit on their periphery : 1. *Articular surfaces.* 2. *Surfaces for insertion.*

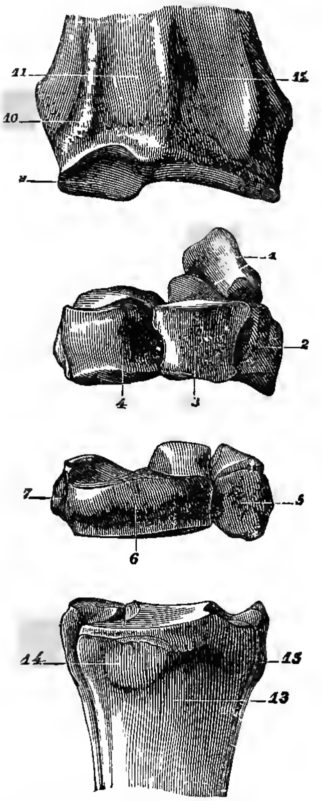
The *articular surfaces* are small, flat, or slightly undulating facets, distributed on the superior, inferior, and lateral faces ; none are found in front or behind. The superior and inferior faces are entirely occupied by a single facet, which responds either to the radius, the metacarpals, or to the bones of the other row. The lateral facets are always multiple, and in contact with the bones of the same tier ; they do not exist, of course, on the outside of the bones at the ends of each row.

The *surfaces for insertion* are absent on the superior and inferior faces ; they separate, in the form of roughened depressions, the lateral articular facets. Before and behind, they are covered by more or less marked rugosities.

Bones of the Upper or Antibrachial Row (Figs. 68, 69).—The *first*, or *os pisiforme*, is outside the row ; it is situated above and behind the carpus, whence its name of *supercarpal bone*, by which it is usually known in veterinary anatomy. This bone, which merits a special description, represents a disc flattened on both sides, offering for study two faces and a circumference. The external face is convex, roughened, and channeled anteriorly by a groove that traverses it from above to below, in which glides the inferior tendon of the external flexor of the

Fig. 68.

A

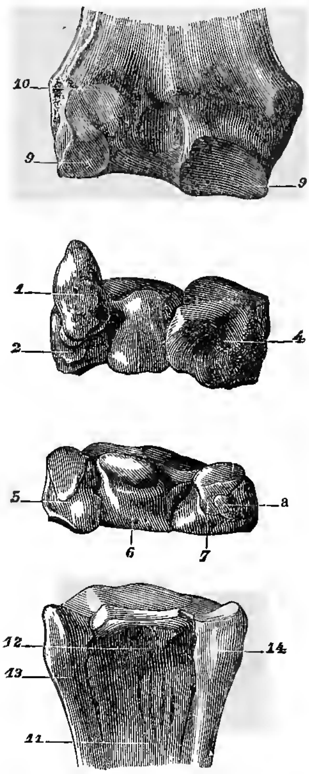


CARPUS OF THE HORSE (ANTERIOR FACE).

1, Pisiform or supercarpal bone (first of the upper row); 2, cuneiform (second ditto); 3, lunar (third ditto); 4, scaphoid (fourth ditto); 5, unciform (first of lower row); 6, os magnum (second ditto); 7, trapezoid (third ditto); 9, inferior articular face of the radius; 10, groove for the oblique extensor tendon of the metacarpus; 11, groove for the anterior extensor of the metacarpus; 12, groove for the anterior extensor of the phalanges; 13, superior extremity of the large metacarpal bone; 14, tubercle for the insertion of the anterior extensor of the metacarpus; 15, superior extremity of the external small metacarpal bone.

Fig. 69.

B



CARPUS OF THE HORSE (POSTERIOR FACE).

1, 2, 3, 4, 5, 6, 7, Same bones as in preceding figure; 8, trapezium (fourth bone of the lower row); 9, 9, inferior articular surface of the radius; 10, transverse crest for insertion of common posterior ligament of the carpus; 11, superior extremity of large metacarpal bone; 12, rugosities in which are fixed the deep layer of the suspensory ligament of the fetlock or superior sesamoid ligament; 13, external small metacarpal; 14, internal ditto.

metacarpus. Its internal face—smooth and concave—concurs in forming the external wall of the carpal sheath. The circumference presents, in front, two articular facets: the superior, concave, corresponds to the radius; the inferior, convex, is in contact with the second bone of the upper row.

The other three bones of this row increase in volume from without to within.

The *second bone*, *os pyramidalis*, or *cuneiform*, articulates with the radius, the first bone of the lower row, the third of the upper, and the supercarpal bone; it has, in all, five articular facets.

The *third*, or *os lunare*, has six facets, and is united below to the first and second bones of the second row.

The *fourth*, or *os scaphoides*—the most voluminous of the row—has only four facets, and articulates by its inferior face with the *os magnum* and *trapezoides*.

Collectively, the second, third, and fourth bones of the upper row form two articular surfaces.

The superior, or radial articular surface, is very irregular; but in examining it from without to within, there may be observed: 1. A glenoid cavity on the cuneiform bone. 2. In front, a transversely elongated condyle on the lunar and scaphoid bones. 3. A groove placed behind the preceding condyle.

The inferior articulating surface, which corresponds to the second row, is constituted by several undulated facets; it is convex outwardly and in front, concave posteriorly and inwardly.

Bones of the Inferior or Metacarpal Row (Figs. 68, 69).—The thickness of these bones decreases from without to within.

The *first*, *unciform*, or *hookbone* (*os hamatum*), has four diarthrodial facets, and responds, above, to the two first bones of the superior row; below, to the first and second metacarpals.

The *second*, *os magnum*, or *os capitatum*—the largest—has seven articular facets, three of which are on the interno-lateral face. It articulates, above, with the lunar and scaphoides; below, with the principal metacarpal and the internal rudimentary metacarpal.

The *third*, or *trapezoides*—the smallest—is provided with five facets, and is in contact with the scaphoides above, and the middle and internal metacarpals below.

Collectively, these bones of the lower row form two large diarthrodial surfaces. The upper surface responds to the bones of the upper row, and is constituted in front, and from without to within, by a small condyle and two glenoid cavities; behind, by two isolated condyles, formed by the os magnum and the trapezoides. The inferior articular surface is only formed by more or less long and plane facets, which incline towards each other. It articulates with the three portions of the metacarpus.

Structure and development.—Each carpal bone is formed by a nucleus of close spongy substance, enveloped in a very thick layer of compact tissue. Each is developed from a single centre of ossification.

The carpal bones of the **Ass** much resemble those of the Horse, but the upper face of the *lunar* is more concave; the facet of the *cuneiform*, for the pisiform, is less concave, but larger and triangular, and is always separated from the superior articular surface by a rough, wide, and deep groove. The *pisiform* is more circular than that of the Horse, and is modified in shape to correspond with the cuneiform; while the inferior surface of the *os magnum* is almost plane in the Ass, but in the Horse it is cut into a condyle in front and a glenoid cavity behind. Lesbre states that the trapezium is more frequent in the carpus of the Ass than the Horse.

The carpal bones of the **Hinny** are like those of the Ass, but those of the **Mule** resemble the Horse.

DIFFERENTIAL CHARACTERS IN THE CARPAL BONES OF OTHER ANIMALS.

A. **Ox, Sheep, Goat.**—In these animals the carpus is composed of only six bones—four in the upper and two in the lower row, where the os magnum and trapezoid are fused together. The pisiform bone is in shape as its name implies, has no groove, and has no relation with the radius. The cuneiform bone articulates with the radius and ulna. The bones of the lower row only articulate with the large metacarpal bone (Fig. 71).

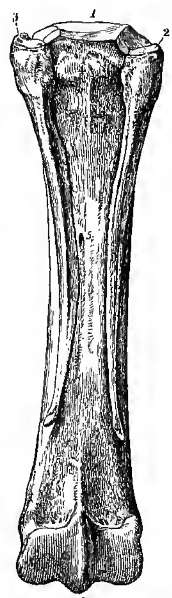
B. **Camel.**—Among the seven carpal bones of the Camel are seen: a pisiform bone, having on its external face a large smooth groove; a lunar, flattened on each side, and deeply notched laterally; an unciform having a pyramidal prolongation behind; an os magnum, smaller than the latter; and a trapezoid, little developed, and entirely removed to the posterior part of the carpus.

C. **Pig.**—The carpus of the *Pig*, like that of Man, contains eight bones—four in each of the rows. The *second* bone of the upper row articulates with the ulna, and to a very small extent with the radius. In the bones of the lower row, it is observed that the first articulates with the two external metacarpals, the second with the great internal metacarpal, the third with the preceding and the small internal metacarpal. The fourth, or trapezium, terminates inferiorly by a blunt point, and has no relations with the metacarpal bones, because the thumb is entirely undeveloped in this animal (Fig. 76).

D. **Dog, Cat.**—In the *Cat* and *Dog* there are also eight bones. Lesbre says, however, that the scaphoid and lunar are sometimes one bone, and that often a *lenticular* bone is found in the upper row. The *cuneiform* bone is very developed, and occupies all the external border of the carpus, articulating with the ulna, first bone of the second row, and the first metacarpal. The *pisiform* bone is elongated, prismatic, thick at both ends, and has in front two contiguous articular facets—one for articulation with the ulna, the other for union with the *cuneiform* bone. The bones of the lower row diminish in size from the first to the fourth, and articulate—the first, with the first and second metacarpals; the second, with the metacarpal of the third digit; the third, with the fourth digit; and the fourth with the metacarpus of the thumb.

E. **Rabbit.**—This animal possesses nine carpal bones; for it is stated that between the two rows there is a piece which Blainville has named the *intermediate bone*. It really belongs to the upper row, and represents the scaphoid. There are, therefore, five bones in the first carpal row of the *Rabbit*, and in this respect the hand of this species more nearly approaches the typical hand than that of the other domestic animals (see the Hand in General).

Fig. 70.



POSTERIOR VIEW OF RIGHT METACARPUS.

1, Head of large metacarpal bone for articulation with the trapezoid, magnum, and unciform; 2, inner splint, rudimentary, or small metacarpal bone, for articulation with the trapezoid; 4, scabrous surface for the attachment of the suspensory ligament; 5, nutrient foramen; 6, median ridge separating the two inferior condyles.

2. METACARPAL BONES (Figs. 67, 70).

In Solipeds, the *metacarpus* is composed of three bones, named the "metacarpals," standing parallel to each other. These are the *principal metacarpal* and the *two rudimentary metacarpals*—an *external* and *internal*.

PRINCIPAL METACARPAL BONE (*os metacarpi magnum*).—This is a long cylindrical bone, situated vertically between the carpus and the digital region.

Body.—The body is a little depressed before and behind, which permits it to be described as having *two faces* and *two borders*. The *anterior face* is perfectly smooth and rounded from side to side. The *posterior face* is flat, and exhibits: 1. Towards the upper third, the nutrient foramen of the bone. 2. On the sides, two narrow, roughened surfaces, parallel and elongated vertically, commencing near the superior extremity, to disappear a little below the middle of the bone; these surfaces are held in apposition to the rudimentary metacarpals, by an interosseous ligament which is often ossified in old Horses. The *borders—external* and *internal*—are very thick, round, and smooth, like the anterior face.

Extremities.—The *superior* is flattened before and behind, and presents. 1. Above, an undulating articular surface, formed by the union of several flat facets more or less inclined towards each other; they articulate with all the lower row of carpal bones. 2. Anteriorly and inwardly, a tuberosity for muscular insertion. 3. Posteriorly—and directly above the roughened surfaces of the posterior face—four small diarthrodial facets in pairs, and running into the larger articular surface by their superior border; they are adapted to similar facets on the rudimentary metacarpals. The *inferior extremity*, elongated transversely, articulates with the first phalanx and the sesamoid bones by an articular surface—convex from before to behind—which is composed of *two lateral condyles* separated by a median spine. The two condyles would be exactly alike, if the antero-posterior diameter of the external condyle were not less extensive than that of the opposite condyle. Both are hollowed on the sides by an excavation for the attachment of ligamentous fasciculi.

Structure and development.—The principal metacarpal is one of the most compact bones in the body. It is developed from two centres of ossification, one of which is for the inferior extremity.

RUDIMENTARY METACARPALS (*ossa metacarpi parva*).—The two rudimentary (*small*) metacarpal (or *splint*) bones are elongated, and placed against the posterior face of the principal bone, one without, the other within. Each is in the form of an inverted pyramid, and exhibits a *middle part* and *two extremities.*

Middle portion.—Prismatic and triangular, this offers: 1. *Three faces*—an *external*, smooth and rounded from one border to the other; an *internal*, plane, and equally smooth; an *anterior*, covered with asperities to give attachment to the interosseous ligament uniting the lateral metacarpal bone to the median. 2. *Three salient borders* which markedly separate the faces from each other.

Extremities.—The *superior*, the largest, is named the *head*, and shows: above, a diarthrodial facet which articulates with one or two bones of the inferior row of the carpus; in front, other two small facets continuous with the preceding, and in contact with similar facets on the large metacarpal bone; on the other points of its periphery are rugosities for the attachment of ligamentous and tendinous fibres. The *inferior extremity* only reaches to about the lower fourth of the large metacarpal bone, and terminates in a small button-shaped enlargement, which is never fused with the latter.

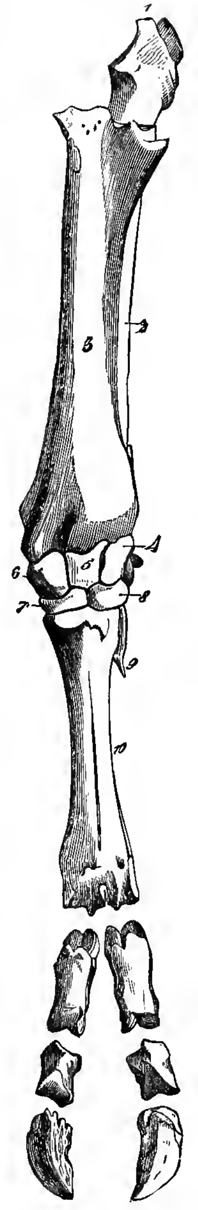
The two small metacarpals, although very much alike, may yet be easily distinguished from each other. For instance, the internal bone is always the thickest, and often the longest; besides, the superior articular surface of its head results from the union of the two facets articulating with the two last carpal bones of the lower tier.

Structure and development.—Of a somewhat compact texture, like all the long bones, these have no medullary canal, and are developed from only one ossifying centre. Not unfrequently, however, the tubercle is formed from a special centre.

The metacarpus of the **Ass** is recognized by: 1. The great inequality of the small metacarpals. 2. The thickness of the large metacarpal (the width is to the thickness as 1·35 : 1 in the Ass, and as 1·53 : 1 in the Horse). 3. The depth of the depressions above the inferior articular surface, posteriorly. 4. The level form of the facet articulating with the *os magnum* of the second row. 5. The presence of a small, flat, vertical facet on the posterior contour of the upper articular surface of the large metacarpal.

In the **Mule** and **Hinny**, the small metacarpals are nearly alike, as in the Horse; the large metacarpal is flattened, as in that animal, with marked depressions posteriorly.

Fig. 71.



FOREARM AND FOOT OF THE OX (FRONT VIEW).

1, Olecranon; 2, body of the ulna; 3, body of the radius; 4, 5, 6, first, second, and third bones of the upper row of the carpus; 7, 8, first and second bones of the lower row; 9, rudimentary metacarpals; 10, principal metacarpals; 11, external digit; 12, internal digit.

Differential Characters in the Metacarpus of other Animals.

The number of metacarpal bones naturally varies with that of the digits:—

In the Carnivora there are	5
In the Pig there are	4
In Ruminants there are	2 or 3

With regard to their shape and form, they offer interesting differences, which will now be studied.

A. **Ox, Sheep, Goat.**—In these animals the metacarpal bones are two in number—a principal, which itself results from the consolidation of the second and third metacarpals; another, altogether rudimentary, situated outwardly; and a third—not constant—embedded in a fibrous cord passing along the inner border of the principal metacarpal.

The principal metacarpal is channeled on its anterior face, and for its whole length, by a deep vascular fissure—a trace of the primitive separation of the bone into two pieces. This fissure presents, inferiorly, the anterior orifice of a canal that completely traverses the bone. The posterior face is also marked by a very slight longitudinal groove. The superior extremity exhibits, externally and posteriorly, a single diarthrodial facet for articulation with the rudimentary metacarpal. The inferior extremity is divided by a deep notch into two articular surfaces, which together resemble the single surface in the Horse; each articulates with one of the digits; the external is always smaller than the internal. In the fœtus, the two long bones that form the great metacarpal are simply laid together, and their medullary canals are separated from each other by the double partition which results from this apposition; after their coalescence, however, the partitions are completely destroyed by absorption, and in a short time there is only a single medullary canal for the entire bone.

The rudimentary metacarpal is only a small osseous stylet, articulating, by a diarthrodial facet, behind and to the outside of the superior extremity of the principal metacarpal; it is sometimes absent in the *Sheep* and *Goat*.

B. **Camel.**—The metacarpus of the *Camel* is very long, quadrangular in its upper two-thirds, and flattened behind and before in its inferior third. Its posterior face is converted into a kind of concave furrow, by the considerably raised borders of the bone. The superior articular surface is divided into two parts by a large roughened depression; the inner part is on a higher level than the outer. The inferior extremity is also divided into two articular surfaces by a very deep notch; each surface is condyloid in its anterior moiety, and is like that of the Horse in its posterior moiety.

C. **Dog, Cat, Rabbit.**—The five metacarpals of the *Dog* and *Cat* articulate with each other, at their superior extremities, by lateral facets; they offer, at their inferior extremity, a condyle prolonged backwards by an articular surface resembling that of the Horse. The middle two are always longer than the two lateral. The smallest belongs to the fifth digit, or thumb, and is terminated inferiorly by a trochlea.

D. **Pig.**—The four metacarpals of the *Pig* articulate with each other, as in the Carnivora. The second and third are larger than the first and fourth. The fifth metacarpal is not developed (Fig. 76).

3. Bones of the Phalangeal or Digital Region (Figs. 72, 73).

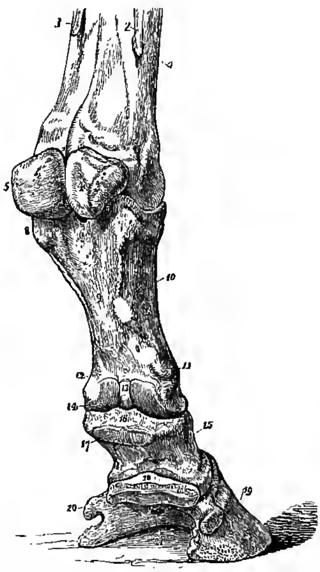
Solipeds have apparently only one digit, supported by the principal metacarpal bone, and composed of three pieces placed end to end, one upon another. The first comprises three bones—a principal, the *first phalanx*—and two complementary ones, the *sesamoids*. The second is formed by the *second phalanx*, and the last, which terminates the limb, is constituted by the *third phalanx*, and an accessory bone which has received the name of the *small sesamoid* (*navicular bone*).

Fig. 72.

LATERAL VIEW OF THE DIGITAL REGION (OUTSIDE OF RIGHT LIMB).

1, Large metacarpal bone; 2, 3, outer and inner sesamoids; 4, first, proximal, os suffraginis, or metacarpal phalanx; 5, its posterior surface; 6, tuberosity for ligamentous insertion; 7, inner condyle of ditto; 8, eminences on second phalanx for attachment of lateral ligament; 9, smooth surface for passage of deep flexor tendon on second phalanx; 10, median or second phalanx, os coronæ, or small pastern bone; 11, navicular bone; 12, third phalanx, pedal, or coffin bone; 13, its basilar process.

Fig. 73.



POSTERIOR VIEW OF THE DIGITAL REGION.

1, Large metacarpal bone; 2, 3, outer and inner splint bones; 4, 5, sesamoid bones; 6, suffraginis; 7, 8, tuberosities for insertion of crucial ligaments; 9, triangular space for insertion of short sesamoid ligament; 10, anterior face of suffraginis; 11, 12, tuberosities for ligamentous insertion; 13, articular depression separating condyles; 14, 15, second phalanx; 16, scabrous surface for ligamentous attachment; 17, smooth surface for gliding of deep flexor tendon; 18, navicular bone; 19, pedal bone; 20, basilar process; 21, plantar foramen.

First (proximal) or Metacarpal Phalanx (Large Pastern Bone, or Os Suffraginis).—The first phalanx (Figs. 72, 73), the smallest of all the long bones, is situated in an oblique direction from above downwards, and behind to before, between the principal metacarpal and the second phalanx.

Body.—Flattened before and behind, this bone exhibits: an *anterior face*, round from one side to the other, and slightly roughened above and below; a *posterior face*, flat, covered with ligamentous imprints in the form of a triangle with the base reversed; *two lateral borders*, thick, rounded, and provided with some imprints.

Extremities.—The *superior*, the largest, presents: Above, an articular surface adapted to the inferior metacarpal surface, and consequently composed of two glenoid cavities separated by a groove running from front to back; laterally, and a little posteriorly, a well-defined tubercle of insertion. The *inferior extremity* has a transversely elongated articular surface, to articulate with the second phalanx; this surface is formed by *two condyles* separated by a middle groove, and surmounted laterally by a small tuberosity for ligamentous insertions. The external condyle is smaller than the internal, and when the bone is placed upon a horizontal plane, the anterior face turned upwards, it only touches by three points—the two tubercles of the upper extremity and the internal condyle; by pressing on the external condyle, it is easy to make the bone oscillate.

The first phalanx is a very compact bone, and is developed from two points of ossification, one of which is for the superior extremity alone. Professors Vachetta and Fogliata, of Pisa, assert that this bone, as well as the second phalanx, has three centres of ossification during uterine life.

Sesamoids (Figs. 72, 73).—These are two small, short bones placed side by side behind the superior extremity of the first phalanx, the articular surface of which it completes, as it has not extent enough to be exactly adapted to the metacarpal surface. Each of these bones represents a small, irregularly shaped polyhedron, or, rather, a short trifacial pyramid. It offers: an *anterior face*, which is articular, and corresponding to the inferior extremity of the principal metacarpal bone, moulded, as it were, on one of the condyles and one of the sides of the median ridge; a *posterior face*, covered with cartilage in the fresh state, and forming, with that of the opposite bone, a gliding concave surface for the flexor tendons of the phalanges; a *lateral face*, studded with ligamentous imprints; a *summit*, directed upwards; and a *base*, turned downwards, and serving for the attachment of several ligaments.

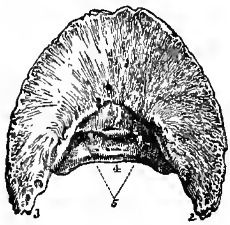
Second (or Median) Phalanx (Os Coronæ, Small Pastern Bone (Figs. 72, 73).—This is a short bone, situated in the same oblique direction as the first phalanx, and between it and the third. Its general form is that of a cube flattened before and behind, and offering the following features: an *anterior face*, covered with some slight imprints; a *posterior face*, provided, above, with a transversely elongated gliding surface; a *superior face*, channeled by two glenoid cavities, to match the inferior articulating surface of the first phalanx; an *inferior face*, formed on the same plan as the last—being occupied by two unequal condyles, which articulate with the third phalanx and the navicular bone; *two lateral faces* exhibiting a very marked imprint. In the interior of this bone is found a nucleus of very condensed spongy substance, enveloped in a layer of compact tissue.

It is usually developed from a single centre of ossification, though in many subjects there is a complementary nucleus for the superior articular and the posterior gliding surface.

Third (Distal or Ungual) Phalanx, Os Pedis (Pedal or Coffin Bone) (Figs. 72, 73, 74).—This is a short bone which terminates the digit, and sustains the hoof that incloses it and the navicular bone. When completed by a special *fibro-cartilaginous apparatus*, it represents the segment of a very short cone, obliquely truncated behind, from the summit to the base. It offers for study: *three faces*, *three borders*, and *two lateral angles*.

Faces.—The *anterior*, convex from side to side, and cribbled by porosities and vascular openings, shows on each side: 1. The *preplantar fissure*—a horizontal groove more or less ramified, which commences behind, between the retrossal and basilar processes, terminating in front in one of the foramina that penetrate the bone. 2. The *patilobe eminence*—a roughened projecting surface, situated between the preceding fissure and the inferior border of the bone. The *superior face* is occupied by an articular surface formed by two glenoid cavities and a slight median ridge; it comes in apposition with the inferior face of the second phalanx. The *inferior* (or *solar*) *face*, hollowed out like an arch, is divided into two regions by the *semilunar crest*, a salient line which describes a curve forwards. The anterior region is perforated with very fine porosities, and corresponds to that part of the hoof named the *sole*. The posterior region shows, immediately behind the semilunar crest, a median imprint, and two lateral channels designated the *plantar fissures*. These originate at the root of the basilar process, are directed obliquely downwards and inwards, and open into the *plantar foramina*, the external orifices of two large canals which enter the bone and unite in its interior to form the *semilunar sinus*.

Fig. 74.



PLANTAR SURFACE OF THIRD PHALANX.

1, Lower face, or sole; 2, 3, wings, or retrossal processes; 4, internal border; 5, plantar foramina.

Borders.—The superior describes a curve, with the convexity forward, and presents: 1. In its middle, the *pyramidal eminence* of the os pedis—a single triangular process, flat before and behind, roughened on its anterior aspect, and concurring, by its posterior surface, to form the articular surface which responds to that of the second phalanx. 2. Laterally, two facets of insertion which encroach on the anterior surface, and even advance, posteriorly, nearly to the preplantar fissure. The *inferior border* is thin, dentated, convex, and semicircular; it is perforated by from five to ten large foramina, which pass into the bone. The *posterior border* is slightly concave; on it is observed a very narrow, transversely elongated, diarthrodial facet, which becomes confounded with the superior large articular surface, and is adapted to a similar facet on the navicular bone.

Lateral angles.—These are two projections directed backwards, on the summit of which the three borders of the bone unite, and which gives attachment to the lateral fibro-cartilages. A deep notch—the origin of the preplantar fissures—separates each into two particular eminences: one, the superior, named by Bouley the *basilar process*; the other, the inferior, prolonged behind, and designated by Bracy Clark the *retrossal process* (from *retro*, behind, and *ossa*, bone).

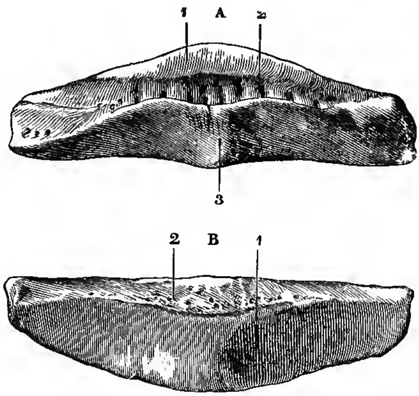
Structure.—The os pedis exhibits in its interior the *semilunar sinus*—a cylindrical, transversely elongated, and semicircular cavity resulting from the arching anastomoses of the two plantar canals. From this cavity pass off numerous channels, which anastomose frequently with each other, and open externally by the foramina on the anterior face of the bone, or by those on its inferior border.

The os pedis has for its base a nucleus of spongy substance, surrounded by a layer of compact tissue. The latter is thicker towards the pyramidal eminence than elsewhere, and sends into the interior numerous prolongations which form the walls of the semilunar sinus, as well as the bony channels which spring from it.

Development.—The third phalanx, formed from a single nucleus of ossification, undergoes numerous changes in its configuration during life. Thus, in the young animal the lateral angles are thick, obtuse, and but little prolonged posteriorly; but as it grows older, they increase in length and become salient. The development they then assume, is due to the progressive ossification of the lateral cartilages implanted on their surface. It often happens, in very old horses, that this ossifying process is carried to an extreme degree, and nearly the whole substance of these complementary organs is invaded. From the commencement, its inevitable result is to convert the notch which separates the basilar from the retrossal process into a foramen.

The complementary fibro-cartilaginous apparatus of the os pedis.—To understand properly the disposition of this portion of the foot, it is necessary that a previous knowledge of the ligaments and tendons attached to the os pedis should have been acquired; therefore a detailed description will be given when the Horse's foot is studied as a whole, in the article on the Sense of Touch. It will be sufficient here to state that this apparatus consists of two lateral pieces—the *fibro-cartilages* of the os pedis, united behind and below by the *plantar cushion*—a fibrous and elastic mass on which rests the navicular bone, through the medium of the perforans tendon.

Fig. 75.



NAVICULAR BONE OF THE HORSE.

A, Anterior Border and Inferior Face. 1, articular facet for the facet on the posterior border of the os pedis; 2, roughened groove on the anterior border; 3, inferior face, smooth and undulated. B, Posterior Border and Superior Face. 1, Articular face for the lower end of the second phalanx; 2, posterior border, with many foramina.

THE SMALL SESAMOID OR NAVICULAR BONE (Figs. 72, 75).—This short bone is annexed to the third phalanx, behind which it is situated; it is elongated transversely, flattened above and below, and narrow at its extremities. It offers: 1. A *superior face*, on which are prolonged the glenoid cavities and the median ridge of the articular surface of the os pedis; it articulates with the second phalanx. 2. An *inferior face*, divided by a slight ridge into two undulated facets, and covered with cartilage to form a gliding surface. An *anterior border*, channeled lengthways by a groove of insertion, above which is remarked a diarthrodial facet that brings the small sesamoid into contact with the posterior border of the third phalanx. 4. A *posterior border* and *two extremities*, for ligamentous insertion. This bone, as well as the sesamoids, originates from a single centre of ossification. It is formed of a layer of compact tissue enveloping a nucleus of very condensed spongy substance. (For differences in the Ass, see Posterior Limb.)

Differential Characters in the Digital Region of other Animals.

In the other domesticated animals, the number of complete digits is as follows:—

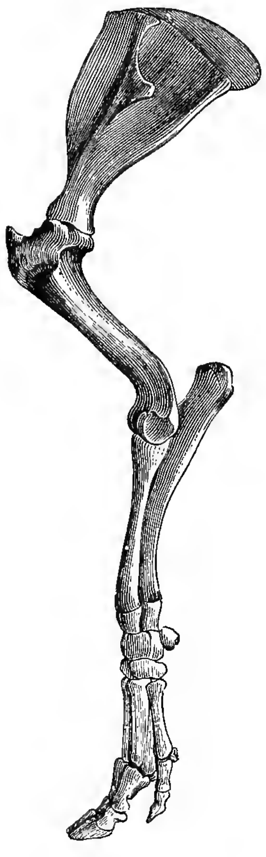
Carnivora	5
Pig	4
Ruminants	2

A. **Ox, Sheep, Goat.**—These animals certainly possess four digits, but only two are perfect—the *médius* and *annularis*—and these articulate with the inferior extremity of the principal metacarpal (Fig. 71). The two others—the *index* and *auricularis*—are in a rudimentary condition, and are represented by two small bones situated above and behind the metacarpo-phalangeal articulation.

In the *Ox*, *Sheep*, and *Goat*, each of the perfect digits comprises (like the single digit of the Horse) three phalanges and three sesamoids.

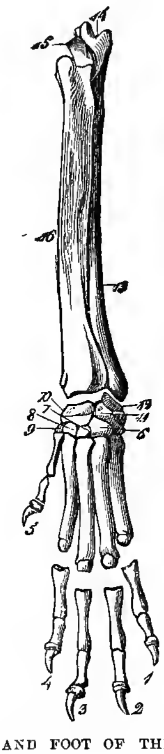
The *first phalanx* fairly represents the moiety of this phalanx in the Horse. It has no

Fig. 76.



Anterior limb of the Pig.

Fig. 77.



Forearm and foot of the Dog (anterior face).

1, First digit; 2, second digit; 3, third digit; 4, fourth digit; 5, thumb; 6, 7, 8, 9, first, second, third, and fourth bones of the lower row of carpal bones; 10, 11, first and second bones of the upper row; 12, supercarpal bone; 13, body of the ulna; 14, apex of the olecranon; 15, beak of the olecranon; 16, body of the radius.

posterior imprints, but shows them on its inner surface for the attachment of several ligaments. This internal face is plane, and the external convex; these characters are repeated in the other two phalanges. It is also remarked in all the phalangeal bones, that the external articular facet of the extremities is always larger than the internal. Of the two *sesamoids*, the external is wider and less elongated than the internal. They articulate with each other and with the first phalanx, by small diarthrodial facets.

The *second phalanx* is hollowed internally by a small medullary cavity.

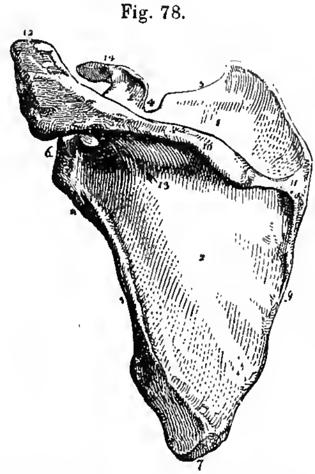
The *ungual phalanx*, as a whole, resembles one of the lateral moieties of the os pedis of Solipeds. This phalanx has no complementary fibro-cartilage, basilar process, or retrossal eminence, nor yet a cavity for insertion on the sides of the pyramidal eminence. The semilunar crest is replaced by an obtuse, thick, and rugged ridge, which occupies quite the posterior limit of the inferior face of the bone. Three large canals penetrate the third phalanx—two to the base of the pyramidal eminence, and one towards the origin of the preplantar fissure. They form, in the interior of the bone, a vast sinus, giving rise to several vascular canals which open on the surface. There is only one foramen at the base of the pyramidal eminence in the *smaller* Ruminants.

B. Camel.—In this animal, there are in each digit only three phalanges and two large sesamoids. The direction and form of these phalanges differ notably from what is seen in Ruminants. The *first phalanx* is long, very oblique, constricted in the middle, and very thick at both ends. On the superior articulating surface is a single glenoid cavity, divided posteriorly by a median groove. The inferior surface is prolonged on the posterior face of the bone, which is converted into a kind of pulley. The *second phalanx* is nearly horizontal, and much flattened above and below. The *ungual phalanx* is somewhat like an irregular trifacial pyramid with a blunt summit; near its base, on its upper face, it has a roughened tubercle.

C. Pig.—The *Pig* has four complete digits articulating from the metacarpals; the thumb is absent. The *index* and *auricularis*—or fourth and fifth digits—are short, and do not usually rest on the ground (Fig. 76).

D. Dog, Cat, Rabbit.—The five digits of the *Dog* and *Cat* are exactly analogous to those of Man. Thus, the external corresponds to the auricularis, the second to the annularis, the third to the medius, the fourth to the index, and the internal to the thumb. The latter, very small, has only two phalanges, and does not come into contact with the ground. Each of the first four is composed: 1. Of a first phalanx, to which are annexed two sesamoids. 2. A second phalanx, which represents a veritable long bone. 3. A conical phalangette, pointed, curved downwards, and hollowed at its base by a circular groove, in which is lodged the matrix of the claw. The small sesamoid (or navicular bone) is absent, but is replaced by a prominence of the ungual phalanx. The auricularis and index are alike, and not so long as the annularis and medius, which are the same in length.

Fig. 78.



HUMAN SCAPULA (EXTERNAL ASPECT).

1, Supra-spinous fossa; 2, infra-spinous fossa; 3, superior border; 4, supra-scapular notch; 5, anterior or axillary border; 6, head of the scapular and glenoid cavity; 7, inferior angle; 8, neck of the scapula; 9, posterior border; 10, spine; 11, triangular smooth surface, over which the tendon of the trapezius glides, with the tuberculum spinæ scapulæ between it and 10; 12, acromion process; 13, nutrient foramen; 14, coracoid process.

Comparison of the Thoracic Limb of Man with that of the Domesticated Animals.

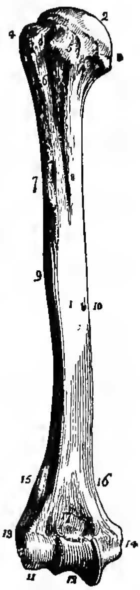
A. Shoulder.—The shoulder of man has for its base two well-developed bones—the scapula and clavicle. The *scapula* (Fig. 78) is more distinctly triangular than that of all the domesticated animals; its vertebral border is also more extensive. The scapular spine, very elevated is continued by an acromion whose extremity reaches to above the scapulo-humeral articulation. The latter is separated from the remainder of the spine by a constriction called the pedicle of the acromion. The coracoid process is voluminous, and resembles a semi-flexed finger. The clavicle extends from the acromion to the sternum; it is flattened above and below, and flexed like an italic *S*. This inflection of the clavicle is more pronounced in the male than the female.

B. Arm.—The *humerus* (Fig. 79) of Man is much longer than that of animals. Its diaphysis is prismatic, and divisible into three faces; the deltoid imprint has the form of a V with its point directed downwards. The voluminous articular head is turned inwards; the bicipital groove is single, and looks outwards. The inferior articular surface resembles that of animals, except that the condyle is more distinct.

C. Forearm (Fig. 80).—The two bones of the forearm, as we have already seen, only articulate by their extremities; they are separated from one another in their middle part. The superior extremity of the *radius* corresponds with the condyle of the humerus; that of the *ulna* articulates with the humeral trochlea. The coronoid process belongs to the ulna. At the lower extremity of the forearm, it is remarked: 1. That the radius corresponds with the greater portion of the carpus, while the ulna only articulates with the pyramidalis. 2. That the radio-carpal articulation is protected outwardly and inwardly by two small osseous prolongations—the styloid processes of the ulna and radius.

D. Hand.—1. *Carpus* (Fig. 81).—The carpus of Man is composed of eight bones—four in each row. The three first of the upper row articulate with the radius; the fourth responds to

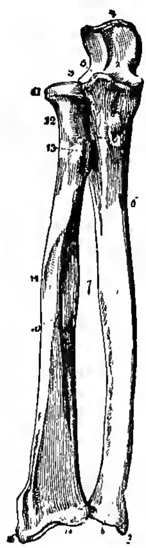
Fig. 79.



RIGHT HUMAN HUMERUS (ANTERIOR SURFACE).

1, Shaft; 2, head; 3, neck; 4, greater tuberosity; 5, lesser tuberosity; 6, bicipital groove; 7, interior bicipital groove; 8, posterior bicipital ridge; 9, rough surface for insertion of deltoid; 10, nutrient foramen; 11, eminentia capitata; 12, trochlea; 13, external condyle; 14, internal condyle; 15, external condyloid ridge; 16, internal condyloid ridge; 17, fossa for the coronoid process of ulna.

Fig. 80.



HUMAN ARM-BONES (FRONT VIEW).

1, Shaft of ulna; 2, greater sigmoid notch; 3, lesser sigmoid notch; 4, olecranon process; 5, coronoid process; 6, nutrient foramen; 7, ridges for insertion of interosseous membrane; 8, capitalum ulnæ; 9, styloid process; 10, shaft of radius; 11, its head; 12, its neck; 13, its tuberosity; 14, oblique line; 15, lower end of bone; 16, styloid process.

the ulna. In the bones of the lower row, the *trapezium* responds to the metacarpal of the thumb and that of the index; the *trapezoides* to the latter only, the *os magnum* and *unciform* to the metacarpals of the medius, annularis, and little finger. The pisiform bone and the cuneiform process of the unciform convert the posterior face of the carpus into a channel.

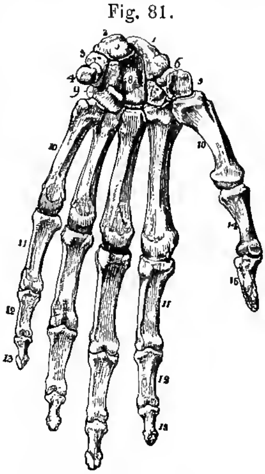
2. *Metacarpus* (Fig. 81).—The five metacarpals of Man are parallel to each other; they articulate by their superior extremities with the bones of the carpus, and by their inferior extremities with the phalanges. They are all concave in their middle portion, and thickened at their ends. The metacarpal of the thumb is the shortest and strongest. The others diminish in volume from the fourth to the first.

3. *Digital Region* (Fig. 81).—Here we find five digits, each composed of three bony columnettes, with the exception of the thumb, in which only the second and third phalanges are present. They decrease in length from the third to the first, and the third to the fifth. The first and second phalanges are small semi-cylindrical bones, slightly thickened at their extremities. The ungual phalanges are constricted in their middle, and widened like a horseshoe at their inferior extremity; the palmar face is roughened, the dorsal face smooth.

Article V.—The Hand in General.

1. The limits of this region, as already mentioned, extend from the lower end of the forearm to the third phalanx, inclusive. If it is examined superficially, the differences it presents in the number and arrangement of the parts composing it are very striking. The digits that terminate the hand are pieces which, from the earliest times, have most occupied the attention of observers. Thus, when we do not go beyond simple appearances, it might be believed that, with regard to the number of digits, there were great differences in animals. From this point of view, the domestic animals form a nearly decreasing series, commencing with the Carnivora and terminating with Solipeds. And in relying upon these appearances, some anatomists have distinguished these animals as *monodactyles*, *didactyles*, and *regular* and *irregular tetradactyles*; but in the generalizations in this work, we have ignored these designations, as they are in complete disaccord with the teachings of philosophical anatomy. In fact, although the Horse appears to have only one digit, the Ox two, the Pig four, the Dog and Cat five, yet the hand in all these creatures may be referred to the pentadactylous type. To demonstrate this unity in composition, the laws promulgated by Gœthe with regard to the vegetable kingdom, and developed and applied to animals by Geoffroy Saint-Hilaire, are accepted; and we have indicated in these few words the laws of analogy and harmony, the principle of relations, the elective affinities, the organic adjustments.

Fig. 81.



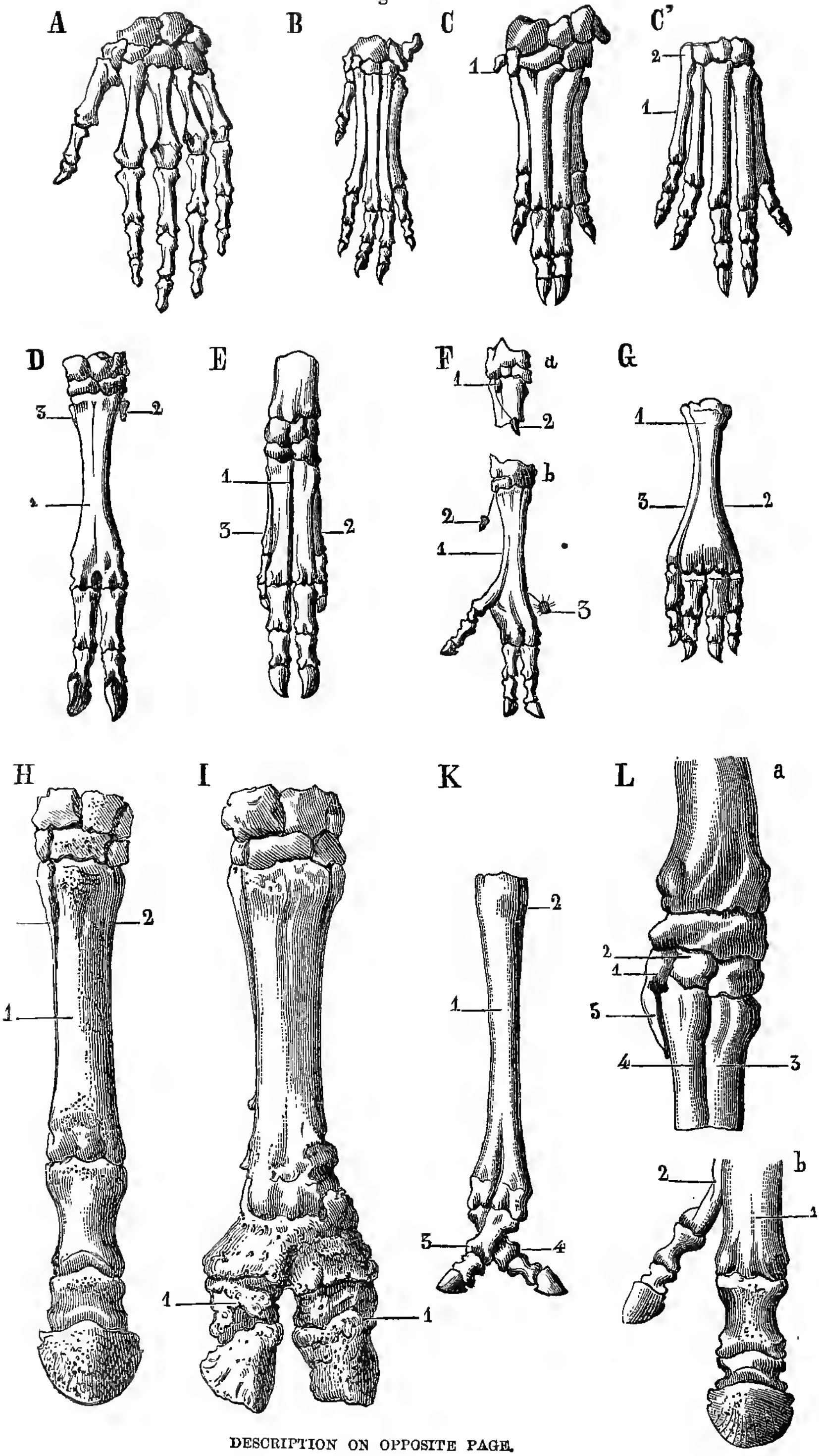
PALMAR SURFACE OF LEFT HUMAN HAND.

1, Scaphoid bone; 2, semilunare; 3, cuneiform; 4, pisiform; 5, trapezium; 6, groove in trapezium for tendon of flexor carpi radialis; 7, trapezoides; 8, magnum; 9, unciform; 10, 10, the five metacarpal bones; 11, 11, first row of phalanges; 12, 12, second row; 13, 13, third row; 14, first phalanx of the thumb; 15, second and last phalanx.

These laws and these principles have been more particularly applied to the study of the hand of animals by Joly and Lavocat, Paul Gervais, Richard Owen, Delplanque, and Arloing. Comparisons, and the attentive study of normal conditions and anomalies, have served as a basis for the conclusions arrived at by these authorities. The anomalies that certain zoologists were tempted to regard as proper facts likely to mislead philosophical anatomists, have, on the contrary, been of assistance to the latter; because, according to the expression of Geoffroy Saint-Hilaire, "an anomaly restores that which we term, in zoology, normal conditions."

2. The Archetypal Hand. The chief type is composed of five digits, and a complete digit in three sections—the carpus, which has two bones; the metacarpus, which has only one; and the phalangeal section, which has three. This constitution of the hand has been conceived by Joly and Lavocat, and reasoning would sanction its acceptance, if it were not presented in some animals

Fig. 82.



DESCRIPTION ON OPPOSITE PAGE.

—such as the *Mole*, *Marmot*, and *Guinea-pig*—each of which have five digits arising from the two carpal bones. In order to study the hand, these authorities place it in its natural position—*pronation*; and the different pieces are reckoned from without to within by the numbers 1, 2, 3, 4, 5.

3. MODIFICATIONS IN THE ARCHETYPE. But the archetypal hand is not constantly realized, even when five digits—such as they are usually understood to be—are present. The human hand, for instance, is formed by five digits and five metacarpal bones, with only eight bones in the carpus. When we go from Man, the number of bones in the three sections is more or less diminished; and in the carpus of the domestic animals, as in that of Man, if the archetypal number does not exist in all the sections, it is because certain pieces have been fused with adjoining ones, or they are not developed. In several instances, certain bones become so atrophied that at the first glance they are not recognizable. Joly and Lavocat at first imagined that these atrophies took place according to some fixed law; they believed that the atrophy operated on the middle part of the bones, extending downwards, and that the last piece to disappear, in an atrophied digit, was that of the carpus.

But since the publication of their first memoires, Lavocat has had occasion to state that this law is not absolute. After these preliminary remarks, we will study the modifications in the archetypal hand in Man and the domestic animals, and demonstrate that in these it may easily be referred to the pentadactylous type.

1. *Man.*—The human hand having five digits and five metacarpal bones, it is rational to admit the virtual existence of five pieces to each of the carpal rows. Materially, there are only four bones in each of these two rows; but the comparative study of the relations of each of these bones in the human carpus, and in that of animals which are in possession of the archetypal hand, leads to the belief that the *scaphoid* is the result of fusion of the fourth and fifth bones of the upper row, and the *unciform* the fusion of the first and second bones of the

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HAND OF MAN AND THE DOMESTIC MAMMALIA, NORMAL AND TERATOLOGICAL (Fig. 82).

A, Human hand (dorsal face).
B, Dog's hand (same position).
C, Pig's hand (normal condition). 1, Trapezium.
C′, Pig's hand: the thumb (1) is completely developed from the trapezium (2).
D, Sheep's hand (normal condition). 1, Principal metacarpal; 2, rudimentary metacarpal, external; 3, ditto, internal (not constant).
E, Hand of the *aquatic Chevrotain*. 1, Double principal metacarpal; 2, 3, lateral metacarpals followed by phalanges.
F, Lamb's hand. *a*, Carpus and superior extremity of metacarpus (seen in profile), on which the metacarpus of the thumb (1) was shown. *b*, Ditto (face): 1, internal rudimentary metacarpal completely developed; 2, horny plate representing the thumb on the surface of the skin; 3, horny plate representing the first digit on the surface of the skin.
G, Lamb's hand on which are four complete digits. 1, Principal metacarpal; 2, 3, lateral metacarpals completely developed.
H, Horse's hand (normal condition). 1, Principal metacarpal; 2, 3, rudimentary metacarpals.
I, Horse's hand, adult (teratological specimen, showing the division of the phalangeal section, 1, 1, of the single digit of Solipeds).
K, Foal's hand (teratological specimen described by Delplanque). 1, Principal metacarpal bifid in its lower third; 2, external rudimentary metacarpal; 3, 4, phalangeal sections resulting from the division of the great digit.
L, Horse's hand, adult (teratological piece). *a*, Carpus (inner aspect): 1, trapezium; 2, trapezoid; 3, principal metacarpal; 4, internal rudimentary metacarpal transformed into a complete metacarpal; 5, styliform piece representing the metacarpal of the thumb. *b*, Inferior extremity of the digital region (inner aspect): 1, principal metacarpal, followed by normal phalanges; 2, internal rudimentary metacarpal transformed into a complete metacarpal, followed by normal phalanges.

inferior row (Fig. 82, A). It is easy, therefore, to refer Man to the most perfect pentadactylous type.

2. *Carnivora.*—The hand of the Dog and Cat has five distinct digits, the internal of which—the thumb—smaller than the others, does not reach the ground (Fig. 82, B). By the metacarpus and the phalangeal section, these animals belong, then, to the pentadactylous type. They appear to be removed from it by the constitution of the carpus, for it has only seven (Dog) or eight bones (Cat) ; there has been fusion of the lunar and scaphoid, but the fifth bone of the upper row is free. The number of bones being thus raised to eight, we know how they may be referred to the archetype—by proceeding in the same manner as for the human carpus.

3. *Rodents.*—The *Rabbit* has five digits, like the Cat, and nine carpal bones. Five of the latter are in the upper row, in consequence of the duplication of the fourth bone, which comports itself as in Carnivora. The scaphoid is between the two rows, as in the tarsus.

The *Rabbit*, therefore, only differs from the archetype by the fusion of the first to the second inferior carpal bone, which sometimes is incomplete.

We have thus demonstrated the pentadactylous composition of the hand in the domestic Carnivora and Rodents—an easy task, as these animals have five apparent digits. We will now pass to the Pig.

4. *Pig.*—This animal has eight carpal bones and four complete digits, with metacarpals and phalanges—two large and two small (Fig. 82, C). There is no difficulty in referring the carpus of the Pig to that of Man or the Carnivora, and from these to the archetype. It suffices to find in this creature a trace of the fifth digit, in order to place it in the pentadactylous type. Normally, the fifth bone of the lower row—the *trapezium*—has no relation with the bones of the metacarpus ; which proves that the remainder of the thumb is absent. But this thumb has been found entirely developed, and having the appearance of the other digits. In Fig. 82 (C′), this has been shown in the teratological cases observed by Joly and Lavocat, and Goubaux and ourselves. Consequently, although the Pig has been classed among bisulcate animals by certain zoologists, yet it has in the anterior limb five digits, more or less completely developed.

5. *Ruminants.*—Intended as an organ of support, the hand of Ruminants offers several fusions or abortions, which increase its solidity at the expense of its suppleness and flexibility. Thus, in the first place, it appears more difficult than in other animals to find, materially or virtually, the elements of the five digits.

Only six bones are found in the carpus of the *Ox*, *Sheep*, and *Goat ;* but the study of relations demonstrates that there are : abortion of the fifth bone of the upper row ; fusion between the first and second, and between the third and fourth, and abortion of the fifth bone, of the lower row. So that, in reality, there are met with, in the carpus of the domestic Ruminants, the elements of ten bones, with the exception of two not developed (Fig. 82, D).

The metacarpus comprises a principal metacarpal—the inferior articular face of which is double—and a styliform bone placed alongside its external and internal borders. For a long time, Geoffroy Saint-Hilaire had demonstrated that the principal metacarpal is formed by two metacarpals brought together during fœtal life, and separated by a more or less incomplete medullary septum during extra-uterine existence. Besides, the isolation of the two metacarpals—temporary in the Ox—is permanent in some other Ruminants, such as the Chevrotain of Guinea and the Aquatic Chevrotain (Fig. 82, E). With regard to the external stylet, it is an atrophied metacarpal; for in some teratological instances it becomes elongated, and supports a more or less perfect digit. In addition, in the Chevrotain it is replaced by the metacarpal and a complete digit (Fig. 82, E). It is the same with the internal stylet, which is usually smaller, and embedded in a fibrous cord running along the large metacarpal; it may, like the external stylet, be converted into a perfect metacarpal (Fig. 82, F and G).

It remains to demonstrate the virtual existence of a fifth metacarpal. Normally, no traces of it are fouud in the domestic Ruminants, bnt it appears in some anomalies. The museum of the Toulouse Veterinary School possesses the hand of a Lamb, in which it can be seen, inside the internal stylet, which has been transformed into a ıong metacarpal—a small styliform bone which is assuredly nothing else than the metacarpus of the thumb (Fig. 82, F, I.). Here is the metacarpus brought to the pentadactylous type; now for the phalangeal region.

The digital region of Ruminants presents two perfect digits (the second and third, Fig. 82, D), and two rudimentary digits reduced to one or two small phalanges covered by a horny plate (ergot), situated behind the metacarpo-phalangeal articulation. The two rudimentary digits may, in certain cases, be reproduced—to the right and left of the normal ones—complete and suspended from real metacarpals. This was seen in a specimen from a young sheep (Fig. 82, G); and this condition is normal in the Chevrotain (Fig. 82, E), only the lateral digits are less voluminous than those appertaining to the principal metacarpal. The presence of the fifth digit is normally indicated, according to Joly and Lavocat, by a tuft or spike of hair inside the carpus, rather above than below it. Sometimes it is better marked; for in the specimen shown in Fig. 82, F′ *a*, where the metacarpal of the thumb had appeared, this digit was represented on the surface of the skin by a plate of horn in the form of an ergot (F, *a* and *b*, 2). Otherwise, in order to dispel all doubts, it may be mentioned that Geoffroy Saint-Hilaire studied a new-born Lamb which had five digits in the anterior limb.

6. *Solipeds.*—In Solipeds, there is apparently only one digit enclosed in one hoof. Nevertheless, by the aid of analogous facts to those which have already assisted us in proving pentadactylism in Ruminants, we shall be able to demonstrate that the hand of the Horse, Ass, etc., is no exception to the general law. Many anatomists only describe seven bones in the carpus of the Horse—four in the upper row, three in the lower. But it is not rare to see a pisiform bone on the inner side of the trapezoid, which raises the number of carpal bones to eight. And Bourgelat, Girard, Rigot, and Goubaux have observed in the carpus of the Horse, in addition to the bones mentioned, a similar piece alongside the external bone of the second row. Lavocat considered this second piece as the first of the inferior carpal bones—the base of the external digit, and that the bone found beside the trapezoid was the trapezium or base of the internal digit or thumb, the trapezoid being the base of the fourth finger. The trapezium and trapezoid are shown, with the significance attributed to them by Lavocat, on the carpus represented in Fig. 82 (L *a*, 1, 2).

The carpus of Solipeds does not differ, then, from the archetype, except in the frequent abortion of the fifth superior carpal bone, and the first and fifth of the lower tier.

The metacarpus of Solipeds comprises a large bone articulating with the digital section, and two rudimentary pieces on each side of it, and which are really atrophied metacarpals ; for in some teratological specimens they are as long as the principal bone, and terminate in a diarthrodial surface which articulates with a perfect digit (Fig. 82, L *b*). At first sight, there are, then, three metacarpals in Solipeds.

With several authorities, and particularly Joly and Lavocat, we have admitted the duplicity of the large median metacarpal bone, basing our admission on several considerations with regard to form and relations, and especially on certain anomalies similar to those represented in Fig. 82, I, in which is seen the single digit of Solipeds divided like that of the Ox—the division extending to the lower end of that bone. But an attentive study of the metacarpal region in the Mammalia, and notably in Pachyderms, and of the arrangement it offers in the various fossil Equidæ, has caused us to abandon this opinion. We consider the principal metacarpal of Solipeds to be the analogue of the metacarpus of the medius of pentadactylous Mammals. With regard to the anomaly shown at I and K, Fig. 82, it should be interpreted as an example of division of an organ normally single.

The Horse, then, has always three metacarpals—one for the medius, the index, and the annularis ; and it remains to prove the existence of two other metacarpals. Usually, the metacarpal of the thumb is completely aborted ; but yet the existence of these bones is indicated by the frequent presence of the trapezium at the inner side of the carpus. Lastly, as a continuation from the trapezium there may be found a conical prolongation (Fig. 82, L *a*, 5), parallel with the metacarpal bone of the index—a prolongation which, because of its connections, should be regarded as the metacarpal of the thumb.

With respect to the metacarpal of the auricularis, or little digit, we do not know of one teratological example in which it can be distinctly seen. But its existence is virtually indicated by the presence of the small external carpal bone we have sometimes observed, and which was noted by Bourgelat, Rigot, and Goubaux.

The phalangeal section only possesses the elements of a single digit. But besides the hoof, Soliped animals have a horny plate divided by a slight median groove, and resting on an elastic cushion behind the metacarpo-phalangeal articulation. This plate occupies the same position as the ergots in the Ox ; it has vessels and nerves from the same source as those of the principal digit ; it lies upon an elastic bed similar to that belonging to that organ ; and Joly and Lavocat regard it as the representative of the phalanges, which should be continued with the rudimentary metacarpals. Otherwise, when one of these metacarpals is developed into a perfect digit, the horny plate or ergot diminishes in volume, because a portion of its substance is carried to the extremity of the supplementary digit. It is, therefore, easy to find three digits in these animals, but the thumb is more difficult to render evident. However, the presence of a trapezius, and, much more rarely, of an atrophied metacarpal succeeding it, would warrant the admission that this digit exists, if it were not represented on the surface of the skin by the chestnut—the horny plate situated on the internal aspect of the forearm. The position of this small mass of horn above the carpus has been invoked against this signification ; but it is easy to overcome this objection in showing, by the ascending vessels and nerves of the chestnut, that this is a displaced organ ; the vessels and nerves arise from the same trunks that supply the other digits.

The fifth digit is not absolutely represented except by its carpal base, which is often absent; however, its presence in a certain number of instances allows it to be affirmed that Solipeds materially and virtually belong to the pentadactylous type. This conclusion applies *à fortiori* to all the domestic animals.

According to statistics drawn up by Cornevin, the return to the pentadactylous type is much more frequently manifested, in Solipeds, in the anterior than the posterior limbs.

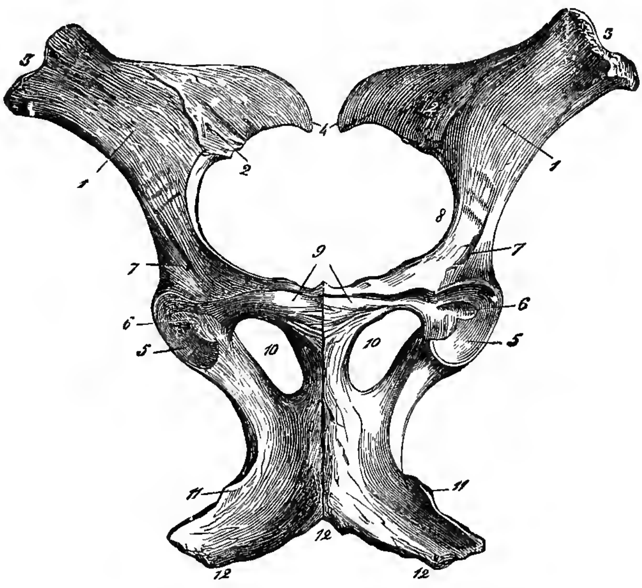
Article VI.—Posterior or Pelvic Limbs.

Each of these is divided, as already noted, into four secondary regions: the *pelvis*, *thigh*, *leg*, and *foot*.

Pelvis (Figs. 83, 84, 85).

The pelvis is a kind of bony cavity formed by the union of the sacrum with two lateral pieces—the *ossa innominata*, or coxæ—which are consolidated with each

Fig. 83.



THE OSSA INNOMINATA (SEEN FROM BELOW).

1, Iliac surface; 2, auricular facet; 3, angle or crest of the ilium; 4, angle of the haunch; 5, cotyloid cavity; 6, bottom of ditto; 7, one of the imprints for the insertion of the rectus femoris; 8, ilio-pectineal line; 9, channel on the external face of the pubes; 10, oval (or obturator) foramen; 11, sciatic spine; 12, 12, ischiatic arch.

other in the inferior median line. The description of the sacrum having been already given, it now remains to speak of the *os innominatum* of each side.

A. Coxa, or Os Innominatum.

The *os innominatum*—also designated *os coxa*, *os iliacum*, *os innominatum*—is a very irregularly shaped flat bone, double (with its fellow on the opposite side), and directed obliquely downwards and backwards. It is contracted in its middle part, which presents externally a deep cavity—the *cotyloid*; anteriorly, where it rests on the sacrum, it becomes widened, as it also does in its posterior portion, which is inflected inwards to be united, on the median line, with the os innominatum of the opposite side.

It is divided, in the fœtus, into three distinct pieces, joined by cartilage in the centre of the cotyloid cavity, which they concur in forming. Although they soon become consolidated into a single piece, it is customary to describe them as so many separate bones by the names of *ilium*, *pubis*, and *ischium*.

Ilium (Figs. 83, 84).—The *ilium*—a flat and triangular bone, curved on itself, directed obliquely downwards, backwards, and outwards—forms the anterior portion of the coxa which corresponds with the sacrum. It is the most considerable of the three divisions, and has *two faces*, *three borders*, and *three angles* or *processes*.

Faces.—The *external* or *superior face* (Fig. 83), studded with some muscular imprints, is excavated on both sides, and is named the *external iliac fossa*. The *internal* or *inferior face* offers for study : 1. An external portion, smooth, and crossed by some vascular grooves ; this is the *iliac surface*, which is replaced in Man by an excavation called the *internal iliac fossa*. 2. An internal portion, roughened and uneven, presents, posteriorly, the *auricular facet*—an irregular diarthrodial surface, elongated from side to side, a little oblique in front and inwards, and responding to an analogous surface on the sacrum.

Borders.—The *anterior border*, or *crest of the ilium*, is slightly concave, and bears a roughened lip for muscular insertion. The *external border* is thick, concave, and furrowed by vascular fissures ; it presents, inferiorly, the nutrient foramen. The *internal border* is thin and concave, particularly in its posterior part, which constitutes the *great sciatic notch*.

Angles.—The *external angle*, or *anterior and superior spinous process*, is thick, wide, and flat, and bears four tuberosities : two superior and two inferior. The *internal angle*, or *posterior and superior spinous process*, represents a rugged tuberosity curved backwards and upwards. The *posterior*—or *cotyloid* angle—is prismatic and very voluminous. It exhibits : 1. Behind, a wide concave articular facet, which forms part of the cotyloid cavity. 2. Above this cavity, the supra-cotyloid crest, represented in Man by the *ischiatic spine*. This is an eminence elongated from before to behind, sharp on its summit, smooth inwardly, roughened outwardly, and continuous by its anterior extremity with the internal border of the bone. 3. Outwardly, two deep imprints for the insertion of the rectus femoris muscle. 4. In front and inwards, the *ilio-pectineal spine*, a small elongated prominence forming the most salient point of a kind of ridge (*linea ilio-pectinea*) that insensibly subsides above on the inner face of the ilium, and is continued below by the anterior border of the pubis.

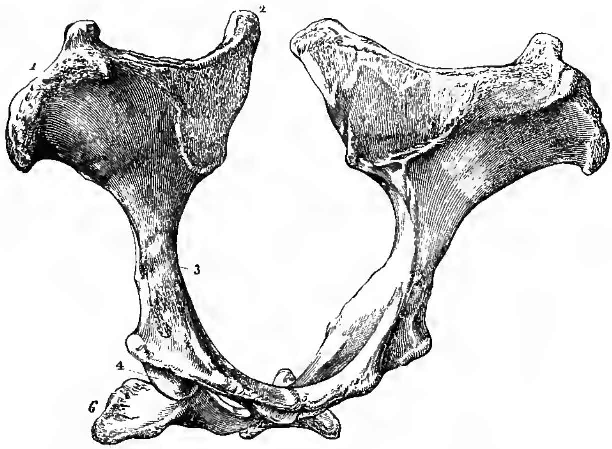
Of the three angles of the ilium, the first is also termed the *angle of the haunch*, and the second the *angle of the croup*.

Pubis (Fig. 83).—Situated between the ilium and ischium, elongated from side to side, flattened above and below, and irregularly triangular, the pubis—the smallest of the three divisions—is divided, for convenience of description, into *two faces*, *three borders*, and *three angles*.

Faces.—The superior, smooth and concave, concurs in forming the floor of the pelvis. It shows one or two nutrient foramina. The *inferior* is roughened, and marked throughout its length by a wide channel which reaches the bottom of the cotyloid cavity. This fissure lodges the pubio-femoral ligament and a very large vein.

Borders.—The *anterior* is constituted by a thin rugged lip, which is curved upwards. The *posterior*, thick and concave, circumscribes anteriorly a wide opening, the *oval*, *subpubic*, or *obturator foramen* ; it is channeled near the coty-

Fig. 84.



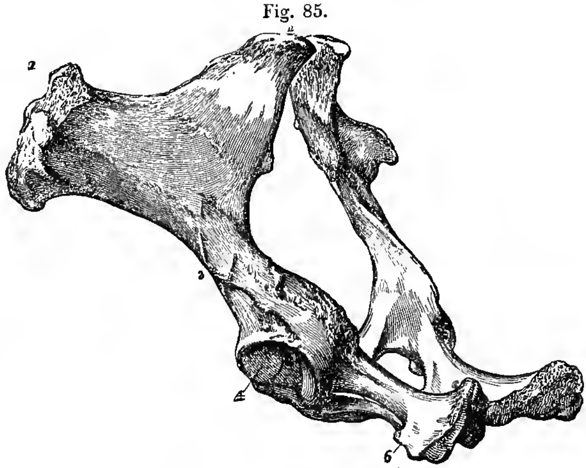
PELVIS (ANTERO-LATERAL VIEW).

1, Anterior iliac spine; 2, posterior iliac spine; 3, shaft of the ilium, with the ilio-pectineal crest; 4, cotyloid cavity; 5, symphysis pubis; 6, inferior ischiatic spine and tuberosity.

loid angle by a fissure which runs obliquely inwards and downwards. The *internal* is united with that of the opposite bone, to form the pubic portion of the pelvic symphysis.

Angles. — The *external*, also named the *cotyloid angle*, is the thickest of the three. To it chiefly belongs the rugged depressed surface that constitutes the bottom of the cotyloid cavity. The *internal* unites with the analogous angle of the opposite bone. The *posterior* is consolidated at an early period with the antero - internal angle of the ischium, to enclose, inwardly, the oval foramen.

Fig. 85.



PELVIS (LATERAL VIEW).

1, External angle of the ilium, or anterior iliac spine; 2, internal angle, or posterior iliac spine; 3, shaft of the ilium and ilio-pectineal line; 4, cotyloid cavity, or acetabulum; 6, inferior ischiatic spine, with tuberosity behind.

ISCHIUM (Figs. 84, 85).—This is the mean, in volume, of the three pieces of the coxa. Situated behind the pubis and ilium, it is flattened above and below, and of a quadrilateral form. It offers for study: *two faces*, *four borders*, and *four angles*.

Faces.—The *superior* is smooth and nearly plane, and forms part of the floor of the pelvic cavity. It has a small nutrient foramen directed outwards. The *inferior* presents some rugosities, clustered particularly about the symphysis.

Borders.—The *anterior*, thick and concave, circumscribes the oval foramen posteriorly. The *posterior*, straight and directed obliquely forwards and inwards, forms, with the analogous border of the opposite bone, a large notch named the *ischial arch*. It exhibits, throughout its extent, a rugged depressed lip (the *spine*), arising from the side of the inferior face. The *external*, thick and concave, constitutes the *lesser ischiatic notch*. The *internal* is joined to the ischium of the other side, to constitute a portion of the pelvic symphysis.

Angles.—The *antero-external*, or *cotyloidean*, is the most voluminous of the four, and affords for study: 1. An excavated diarthrodial facet, making part of the cotyloid cavity. 2. The posterior extremity of the supra-cotyloidean crest, limited by a small transverse fissure which separates from the external border of the bone. The *antero-internal angle* is consolidated with the posterior angle of the pubis. The *postero-external angle* forms the *ischial tuberosity*. This is a large prismatic process which looks upwards, and is prolonged by a salient ridge, elongated from before to behind, with its sharp border turned outwards and downwards. The *postero-internal angle* forms, with that of the other ischium, the summit of the triangular space which constitutes the ischial arch, or pubic arch of some species.

THE COXA IN GENERAL.—This bone, the three constituent parts of which we have just been studying, presents for consideration, as a whole, a middle portion and two extremities. The middle, very much contracted, offers, outwards and downwards, the *cotyloid cavity* (or *acetabulum*), which has not yet been described, because its study does not properly pertain to either of the three regions of the coxa. This cavity is intended to receive the articulating head of the femur, and represents the segment of a hollow sphere; it is circumscribed by a very salient rim, which is thin at its free margin, and widely notched on the inner side. The deeper portion is occupied by the roughened and depressed surface already designated as the *bottom* of the cotyloid cavity (*fundus acetabuli*), which communicates, by the internal notch of the rim, with the inferior groove of the pubis. The anterior extremity, flattened on both sides, and formed by the ilium, rests, as has been shown, on the sacrum. The posterior extremity, flattened in an inverse sense to the preceding, is constituted by the pubis and the ischium, and is traversed, from above to below, by the *sub-pubic* (or *obturator*) *foramen*—the large oval aperture which separates these two bones from one another, and perforates the floor of the pelvis; this opening is closed in the fresh state by muscles.

The two coxæ, by uniting in their posterior part, form the articulation to which has been given the name of *ischio-pubic* or *pelvic symphysis;* thus united, the two bones represent something like a V with the opening in front—a circumstance which makes the lateral diameter of the pelvis greater in front than behind.

STRUCTURE AND DEVELOPMENT OF THE COXA.—To the three centres of ossification which constitute the coxa, are added two complementary centres: one for the anterior spinous process and spine of the ilium, another for the ischial tuberosity.

It must be added that there is, within and in front of the cotyloid cavity, a *cotyloid nucleus* analogous to the glenoid nucleus of the scapula. This nucleus, comprised between the three bones of the coxa, has been named by Serres the Y-shaped bone.

In youth, the different parts of the coxa are very thick, and the spongy tissue is abundant, while the compact is rare. The pubis is always convex on its two faces, and the middle part of the coxa—that adjoining the cotyloid cavity—is of considerable thickness, a feature which much diminishes the extent of the pelvic cavity. As the animal advances in age, however, the layers of compact tissue increase in thickness, approaching each other as the spongy substance is lessened. The pubis becomes thinnest, and at an advanced period of life is sometimes even translucid.

The compact tissue is always abundant in the neighbourhood of the cotyloid cavity, as this is the centre on which converge all the impulsive efforts communicated to the trunk by the posterior limbs. It is also in this cavity that ossification commences.

B. The Pelvis in General.

1. External and Internal Conformation of the Pelvis.—The pelvis is a kind of rear cavity in the form of a cone, which prolongs the abdominal cavity between the sacrum and coccygeal vertebræ.

It occupies the posterior part of the trunk, and, with regard to its conformation, presents for study an external and internal surface.

External surface.—This may be resolved into four planes or faces.

The *superior plane* is slightly oblique from above to below, and before to behind; its degree of obliquity varies. It is contracted from before to behind, and shows: 1. On the median line, the spinous processes of the sacral and the first coccygeal vertebræ. 2. On each side the sacral grooves, at the bottom of which open the supra-sacral canals.

The *inferior plane* is nearly horizontal. Formed by the pubes and ischial bones, it presents from before to behind: 1. In the middle, the ischio-pubic symphysis. 2. On each side the subpubic groove, the oval foramina, and the inferior face of the ischial bones. 3. Quite externally, the cotyloid cavities, by which the pelvis rests upon the posterior limbs.

The *lateral faces* are oblique downwards and outwards, and are wider in front than behind. They exhibit: 1. The spine of the ilium and the two anterior spinous processes. 2. The external iliac fossa. 3. The ischial arch. 4. The supra-cotyloid crest or ischiatic spine, which presents, outwardly, the surface of insertion for the internal or deep gluteus muscles. 5. The lesser ischiatic notch. 6. The ischial tuberosity.

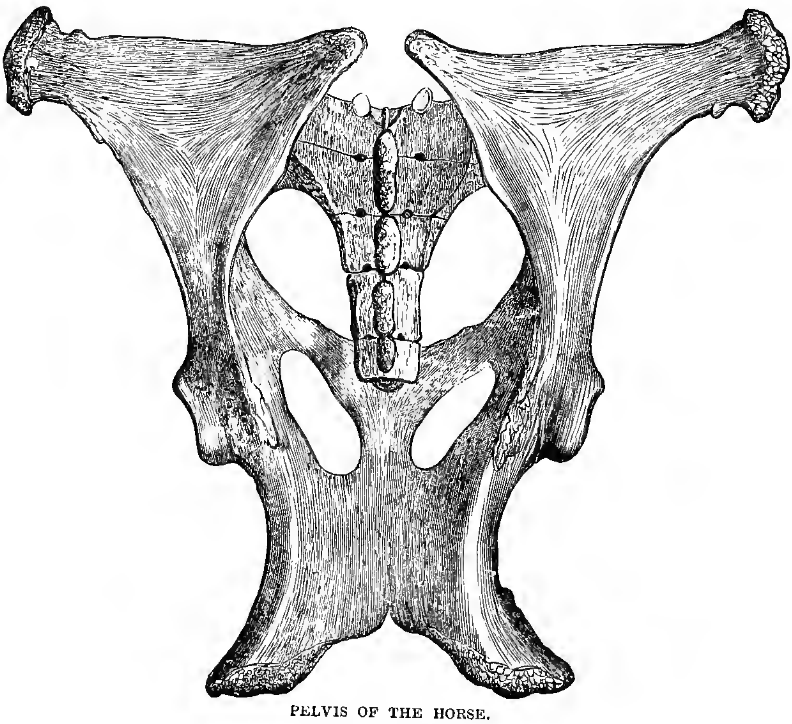
Internal surface.—The internal surface of the Horse's pelvis cannot be divided into two portions as in Man, because the inner surface of the iliac bones is not hollowed out to form an anterior cavity.

The pelvis of Solipeds is, therefore, a simple conoid cavity, in which are distinguished four planes or faces, and two apertures called the *inlet* and *outlet.*

The *anterior opening*, or *inlet*, is nearly circular, especially in the Mare, and a little oblique downwards and backwards. It is limited above by the inferior face of the first vertebra of the sacrum; inferiorly, by the anterior border of the pubis; and on the sides by a part of the inner face of the iliac bones, and also the internal aspect of the pectineal crests.

The inlet presents four *diameters*, a knowledge of which is important in obstetrics—a vertical, horizontal, and two oblique. The first, the *sacro-pubic*, extends from the inferior face of the sacrum to the anterior border of the pubic symphysis; its mean length is $8\frac{1}{4}$ inches. The second, the *bis-iliac*, is measured from one pectineal crest or eminence to another; the mean of this is $8\frac{6}{10}$ inches. The two last diameters, the *ileo-sacral*, are estimated from the inferior face of the sacro-iliac articulation of one side to the ilio-pectineal eminence of the other; this is, on an average, $8\frac{7}{10}$ inches. These measurements irrefutably

Fig. 86.



PELVIS OF THE HORSE.

demonstrate that the inlet is not elliptical in the vertical direction; but it may happen that the transverse diameter is the greatest.

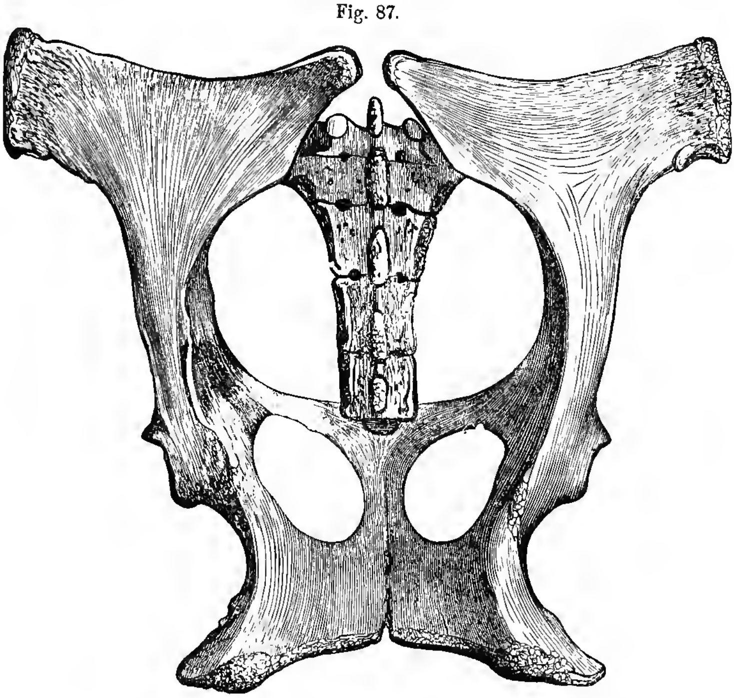
The *posterior aperture* or *outlet*, situated at the posterior end of the pelvic cavity, gives exit to the rectum and genital organs. It is limited by the inferior face of the summit of the sacrum, the superior face of the ischial bones, the supra-cotyloid crest or ischiatic spine, and the internal face of the sacro-sciatic ligaments. At the outlet only two diameters are recognized—a vertical and a horizontal. The vertical, extending from the inferior face of the sacrum to the superior face of the ischial symphysis, measures on an average $6\frac{7}{10}$ inches. The horizontal diameter, comprised between the two supra-cotyloid crests, is $7\frac{7}{10}$ inches.

The *superior face* of the pelvic cavity is a little concave from before to behind; it has for base the sacrum, which presents on each side of the median line the subsacral foramina. This part is also called the sacral plane, or roof of the pelvis.

The *inferior region*, or ischio-pubic plane, is formed by the pubes and the ischial bones. It is concave from side to side; its anterior border is nearly straight, and its posterior border is scooped out by a wide notch to form the *arch of the ischium*.

It has been remarked by Goubaux, that the portion of this plane corresponding to the pubis presents numerous varieties. The superior face of the pubis may be convex in its anterior moiety, and concave in its posterior; or it may be

Fig. 87.



PELVIS OF THE MARE.

concave before and convex behind, the concavity being separated from the convexity by a transverse ridge. This ridge is sometimes represented by a series of small conical eminences; at other times this upper face is disposed as a smooth inclined plate, directed backwards and upwards, and a kind of rim surmounts the anterior contour of the oval foramen.[1]

With regard to the *lateral faces*, they are formed by a small portion of the inner face of the iliac bones, and in great part by the sacro-sciatic ligaments.

The fœtus must pass through the pelvic canal during parturition; it is, therefore, important to know at any time if the female pelvis is of sufficient dimensions to allow the fœtus to leave it. *Pelvimetry* is the name given to

[1] It is necessary to be aware of the frequency of these asperities on the floor of the pelvic cavity, in order not to arrive at false inductions when exploring the bladder *per rectum*.

that section of obstetrics dealing with the diameters of the pelvis. These may be determined in several ways, which, in veterinary surgery, daily receive the sanction of experience.

Some years ago we indicated one,[1] which consists in measuring the horizontal distances between the two haunches and the two ischiatic tuberosities, and the vertical distance extending from the coxo-femoral articulation to the most salient part of the croup; then to take a fourth of the total of the two first measurements, in order to obtain the transverse diameter of the inlet, and three-fourths of the third, to have the vertical diameter of this opening.

Saint-Cyr and Violet have investigated the relation existing between the height of the Mare and the vertical diameter of the pelvis, then that of the width of the croup to the bis-iliac diameter; and they have found that the first was equal to 0·1515 centimetres; the second to 0·4654, in a well-bred Mare, to 0·3945 in common-bred Mares. Consequently, according to the pelvimetric procedure of these authorities, it is sufficient to multiply the height of the Mare by 0·1515 to have the vertical diameter of the inlet, and the width of the croup by 0·4654 or 0·3945, according to circumstances, to find the transverse diameter. But this question rather appertains to obstetrics.[2]

2. Differences in the Pelvis of the Sexes.—The pelvis of the Mare exceeds that of the Horse in all its dimensions, but the difference is most marked in the transverse diameters (Figs. 86, 87).

The inlet forms a vast circumference, when compared with that of the male; the pectineal crests are wide apart, and the distance separating the anterior border of the pubis from the lower face of the sacrum is considerable.

If the pelvis be viewed in its superior plane, it is found that in the Mare the ischiatic notches are very deep; that the internal border of the ilium forms a regularly curved and very concave line; and that the supra-cotyloid crests, or ischiatic spines, are widely separated from each other. It is also noticed that the floor of the pelvis is wide, and that the bones composing it tend towards the same horizontal line.

In the male, the ischiatic border is only represented by a very curved line; this line is composed of two almost straight portions, which join at an obtuse angle at the origin of the neck of the ilium; the supra-cotyloid crests are relatively near each other, and bent towards the longitudinal axis; while the two moieties of the pelvic floor are directed very obliquely downwards and inwards.

In the Mare, the ischial arch is larger than in the male, and forms a regular curve uniting the two tuberosities of the same name. In the Horse, the two ischial tuberosities are but little apart, and the ischial arch forms a somewhat acute angle, with its borders nearly straight.

Lastly, when the pelvis is examined in its inferior plane, in addition to the features already indicated in the ischial arch, it is found that in the Mare the obturator foramina are large and nearly circular, while in the Horse they are elliptical; the cotyloid cavities are also further removed from the ischio-pubic symphysis in the female than in the male.

The sacrum of the Mare has appeared to us, in some individuals to be a little more arched from before to behind than that of the Horse; but this character is not constant.

[1] Arloing, *Journal Vetérinaire de Lyon.* 1868.

[2] Saint Cyr and Violet, *Traité d'Obstetrique Vétérinaire.* Paris: 1888.

The following figures, relating to the capacity of the pelvis of the Mare and Horse, confirm what has just been enunciated :—

Mare. Horizontal Diameters.		Horse. Horizontal Diameters.	
Between the Pectineal Crests.	Between the Supra-cotyloid Crests.	Between the Pectineal Crests.	Between the Supra-cotyloid Crests.
Inches. $9\frac{1}{5}$	Inches. $7\frac{1}{2}$	Inches. $8\frac{1}{14}$	Inches. $6\frac{4}{10}$

Mare. Vertical Diameters.		Horse. Vertical Diameters.	
Between the Sacrum and Pubis.	Between the Sacrum and Ischium.	Between the Sacrum and Pubis.	Between the Sacrum and Ischium.
Inches. $8\frac{9}{10}$	Inches. $6\frac{9}{10}$	Inches. 8	Inches. $6\frac{3}{10}$

To recapitulate, there is observed in the pelvis of the Mare :—

1. A great increase in the transverse diameters.
2. A deep and regularly concave ischiatic notch.
3. A wide and concave ischial arch.
4. Circular obturator foramina.
5. The cotyloid cavities distant from the pubic symphysis.

In the **Ass**, the inlet of the pelvis is a longer oval than in the Horse. The coxæ are distinguished by : 1. The less curvature of the anterior border of the ilium. 2. A slightly excavated external iliac fossa. 3. The triangular shape of the obturator foramina. 4. A short and deep notch separating the external border of the ilium from the angle of the haunch. 5. The direction of the tuberosities of this angle ; they approach more nearly the parallelism with the median plane of the trunk than in the Horse. 6. The disposition of the rugosities in tubercles for the insertion of the suspensory ligaments of the corpus cavernosum on the inferior face of the ischium. In the Ass, also, a line which would unite the inferior contour of the auricular facet to the most salient point of the angle of the haunch, would be parallel to the anterior border of the ilium, while it would be oblique on this border in the Horse.

The inlet of the pelvis in the **Hinny** resembles that of the Ass ; in that of the **Mule**, it holds a middle place between the Ass and Horse. The pelvis of the Hinny resembles that of the Ass, also, by the form of the obturator foramina, the direction of the anterior border of the ilium, and the position of the auricular facet ; while that of the Mule, on the contrary, resembles the pelvis of the Horse in these features. The reverse is noted with regard to the disposition of the angle of the haunch.

Differential Characters in the Pelvis of other Animals.

It is remarked : 1. That in all the domesticated animals, with the exception of Solipeds and the Camel, the direction of the coxæ is nearly horizontal. 2. That in all, the ilium is more oblique than in Solipeds. 3. That in all, the transverse diameters of the pelvis are relatively less extensive.

A. Ruminants.—In the *Ox*, the space between the two coxæ is scarcely so great in front as behind; the ilium is not voluminous, and has only three processes on the anterior and superior iliac spines. There is no furrow on the lower face of the pubes, and its upper face, like that of the ischium, is very concave. Three eminences are seen on the postero-external angle of the ischium. In early life, the ischio-pubic symphysis shows an epiphysary nucleus in the middle of its inferior face. (The epiphysis on the inner border of the ischium has been considered by some anatomists as an independent bone, and described by them as the *inter-ischial bone*).

The ischio-pubic symphysis has, in the middle of its inferior face, a thick protuberance, flattened on each side and very pointed; in early life this is an epiphysis, and the epiphysary nucleus, bifurcated posteriorly, is continued along the posterior border of the ischial bones as far as the ischial tuberosity, in the form of two marginal bands.

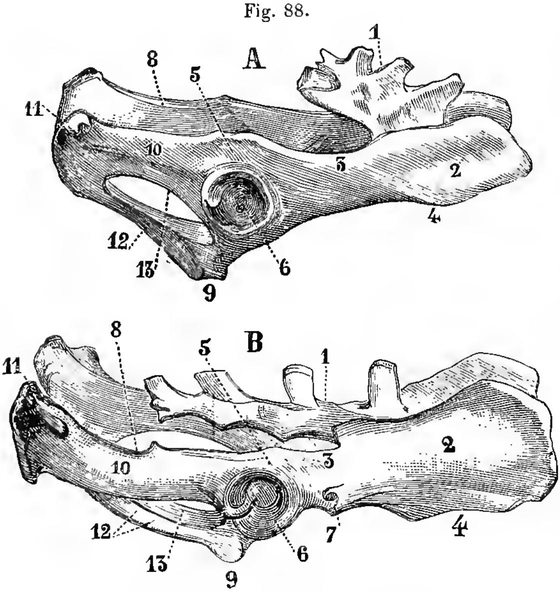
The rim of the cotyloid cavity has also three notches, and the supra-cotyloid crest, or ischiatic spine, is very elevated and sharp, and but little roughened outwardly.

In the *Sheep* and *Goat*, the coxæ are yet more horizontal and proportionately longer than in the Ox, but the upper face of the ischium and pubis is less concave; the external iliac fossa is separated into two portions by a small longitudinal crest.

The pelvis of the *Camel* is remarkable for its great obliquity, its shortness, and its narrowness. The anterior border of the ilium is convex; the pubis and ischium are very thick; the rim of the cotyloid cavity is elevated and regular; the ischio-pubic symphysis forms a rugged crest outside the pelvis; and the ischial tuberosity is disposed in the same manner as in the Horse.

B. **Pig.**—The pelvis of the *Pig* closely resembles that of the smaller Ruminants; though the crest of the ilium is convex, and there is no protuberance outside the ischio-pubic symphysis.

Fig. 88.



PELVIC BONES OF THE CAT AND RABBIT.

A, Pelvis of the Cat. B, Pelvis of the Rabbit. 1, Sacrum; 2, external iliac fossa; 3, great ischiatic notch; 4, external border of the ilium; 5, supra-cotyloid crest; 6, cotyloid cavity; 7, crest above the shaft or neck of the ilium; 8, small sciatic notch; 9, anterior extremity of the symphysis pubis; 10, ischium; 11, ischial tuberosity; 12, pubis; 13, obturator foramen.

The pelvic cavity is vast, in proportion to the animal's height, and the ischio-pubic symphysis is late in becoming ossified.

C. **Dog.**—In the *Dog*, the transverse diameter of the pelvis is greater behind than in front; it is smallest between the cotyloid cavities. The ilium is nearly vertical, and its external face is much depressed. The notch forming the ischial arch occupies no more than the internal moiety of the posterior border of the ischium; between this arch and the ischial tuberosity, is a rugged lip directed downwards. There is no furrow on the lower face of the pubis. Ossification of the symphysis is even later than in the Pig.

D. **Cat.**—In the *Cat*, the ilium is proportionately narrow, and the supra-cotyloid crest higher, than in the Dog. The posterior border of the ischium is regularly convex from without to within, and the pubic symphysis has, inferiorly, a somewhat salient crest (Fig. 88).

E. **Rabbit.**—Pelvis horizontal; ischium nearly as long as the ilium; external iliac fossa divided by a blunt longitudinal crest; supra-cotyloid crest little elevated, straight, and ending abruptly behind by a kind of notch; rim of the cotyloid cavity complete, or having a slight posterior notch; ischial tuberosities parallel and not divergent, as in the Dog; and posterior border of the ischium concave, and very obliquely directed forwards and inwards (Fig. 88).

Thigh.

This has for its base one bone—the *femur*.

Femur (Figs. 89, 90).

The *femur* (*os femoris*) is a long, pair bone situated in an oblique direction downwards and forwards, between the coxa and the principal bone of the leg; it is divided into a *body* (or *shaft*) and *two extremities*.

Body.—It is irregularly cylindrical, and presents for study *four faces*. The *external*, *internal*, and *anterior*, confounded with one another, are regularly rounded and almost smooth, showing only some slight impriuts and vascular grooves. The *posterior*, nearly plane, and wider above than below, offers: 1. Outwardly and towards the superior third, an uneven circular surface. 2. On the same level, and inwardly, a slight crest, oblique downwards and outwards. 3. In the middle, a very extensive roughened surface, having the form of an obliquely angular parallelogram, for the attachment of the great adductor muscle of the thigh. 4. Below this surface, a large vascular groove running obliquely outwards and downwards.

On the limit of the posterior and external faces are found, towards the upper third, a large rugged, flattened eminence, curved in front, and termed the *subtrochanterian crest* (or *external small trochanter* [1]), because of its position under the trochanter; below, a deep fossa, named the *subcondyloid*, garnished at its bottom with asperities, and bordered in front by an uneven lip. On the limit of the posterior and internal face, there are observed from above to below: 1. The *small trochanter*—a large scabrous tuberosity, elongated in conformity with the bone, and situated near its upper fourth. 2. A marked longitudinal imprint for the attachment of the pectineus; behind, it is confounded with the surface for the insertion of the great adductor muscle of the thigh, and presents, in front, the nutrient foramen of the bone. 3. The origin of the great posterior fissure. 4. Quite below, a collection of large tubercles which form the *supracondyloid crest*.

Extremities.—The *superior extremity* is sensibly flattened before and behind, and shows: 1. Inwardly, an articular head which is received into the cavity of the acetabulum. This head is separated from the other portion of the body by a neck, which is, however, not well marked in the Horse, and forms two-thirds of a sphere, excavated in its internal part by a very deep cavity for ligamentous insertion. 2. Outwardly, a very large eminence—the *trochanter major*, or *great* (*external*) *trochanter*, in which is recognized, as in the trochlea of the humerus: a *summit*, much more elevated than the articular head, and slightly bent inwards; a *convexity*, encrusted with cartilage, and anterior to the summit, from which it is separated by a narrow and deep notch; a *crest* situated under the convexity, and formed by a tuberculated surface, on which one of the tendons of the middle gluteus muscle becomes inserted, after gliding over the convexity. 3. Posteriorly, the *trochanteric* or *digital fossa*—a deep cavity studded with imprints, and circumscribed, outwardly, by a salient lip (*trochanteric ridge*), which descends vertically

[1] This is the third trochanter of Cuvier, and takes the place of the external and superior branch of the *linea aspera* of Man. (It is the *external small trochanter* of Percivall, and the *middle trochanter* of Leyh.)

from the summit of the trochanter to the posterior face of the bone, where it gradually subsides.

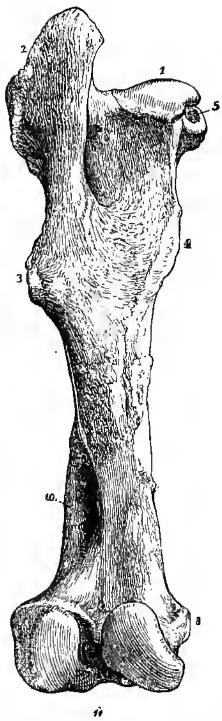
The *inferior extremity* is flattened before and behind ; consequently, its larger axis crosses at a right angle that of the upper extremity. It is distinguished by the presence of *two condyles* and *a trochlea.* The *two condyles*, placed behind, one beside the other, articulate with the superior extremity of the tibia. They are separated by a deep depression designated the *intercondyloid fossa*, which lodges the spine of the tibia and the interosseous ligaments of the femoro-tibial

Fig. 89.

LEFT FEMUR (ANTERIOR VIEW).

1, Head; 2, 2, trochanter major, with its crest; 3, trochanter minor, subtrochanterian crest, or third trochanter; 4, internal trochanter; 5, notch for insertion of ligamentum teres; 7, 8, tuberosities for tendinous and ligamentous insertion; 9, trochlea.

Fig. 90.



LEFT FEMUR (POSTERIOR VIEW).

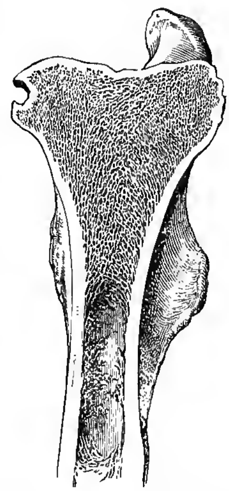
Head; 2, trochanter major; 3, trochanter minor; 4, internal trochanter; 5, fossa for insertion of ligamentum teres; 6, trochanteric fossa; 7, 8, tuberosities; 9, fossa for the insertion of the external meniscus; 10, supra-condyloid fossa; 11, condyles.

articulation. The *external condyle* bears, outwardly, two fossæ—one superior, for ligamentous insertion ; the other, inferior, for muscular attachment. The *internal condyle* presents, posteriorly and inwardly, near the posterior extremity of the intercondyloid notch, a roughened depression for the insertion of the fibro-cartilaginous meniscus interposed between the external condyle and the corresponding articular plane of the tibia. It is surmounted outwardly—on the side opposite to the intercondyloid notch—by a large tubercle for insertion. The *trochlea*, a wide pulley on which the patella glides, is situated in front of the condyles. It is slightly oblique downwards and inwards, and appears to continue in front the intercondyloid notch. Of the two lips which border its cavity laterally, the internal is the thickest and the most prominent. Between the external and the corresponding condyle, is seen a digital fossa for muscular insertion.

Structure and development.—The femur, very spongy at its extremities, is developed from four principal centres of ossification: one for the body, another for the articular head, the third for the trochanter, and the last for the inferior extremity alone.

The femur of the **Ass** offers several differential characters, the principal of which have reference to the length of the neck, the development of the third trochanter (*trochanter minor*), and the curvatures of the diaphysis. The greater length of the neck causes the internal trochanter to be some distance from the horizontal plane on which the inner face of the bone lies; in the Horse this trochanter is always in contact with the plane. The small trochanter is less developed than in the Horse, as may be seen on laying the bone on its external border; for the femur of the Ass rests by the trochanter major and external condyle, while in the Horse, it lies on the latter and the subtrochanteric crest. With regard to the curvatures, there is remarked a slight diminution in that which carries the head of the bone backwards, and a slight increase in the twist of the diaphysis around its longitudinal axis, which alters the equilibrium of the bone; so that it is impossible to have it in stable equilibrium when it rests on the trochanter major, head, and inner lip of the trochlea; this is easily accomplished with the femur of the Horse.

Fig. 91.



SECTION OF LEFT FEMUR, SHOWING ITS STRUCTURE.

By the dimensions of the neck and internal trochanter, the femur of the **Hinny** and **Mule** holds a middle place between their progenitors; while in the development of the trochanter major, and the degree of torsion around its longitudinal axis, the femur of the Hinny much resembles that of the Ass, and the Mule that of the Horse, though the conditions of equilibrium always remain the same as in the latter.

Differential Characters in the Thigh-bone of the other Animals.

In all the domesticated animals except Solipeds, the *femur* tends to become curved longitudinally, prismatic, and triangular; the posterior face contracts, and the surfaces for insertion that it presents gradually approach each other, until they become confounded, and form a *linea aspera* in certain species. The head is more distinct; the internal trochanter is a rough tubercle, and is joined to the large trochanter by an oblique ridge; the large trochanter subsides, and forms a single mass, the summit and convexity of which are confounded; the third trochanter, the fossa, and the supra-condyloid crest are more or less effaced. In addition to these modifications, there are others special to each species.

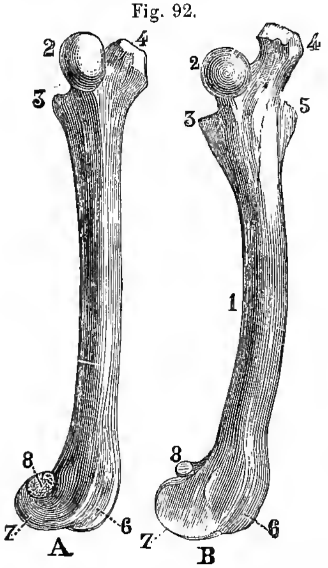
A. **Ruminants.**—In the *Ox*, there is no subtrochanteric crest; the supra-condyloid fossa is shallow, and the crest little noticeable. The head is well detached, and has its centre excavated by a shallow fossa of insertion. The trochlea is narrow, and its inner border ascends much higher on the anterior face of the bone than the external.

In the *Sheep* and *Goat*, the general form of the femur resembles that of the Ox. It is observed, however, that the body is slightly curved backwards; that the supra-condyloid fossa is nearly obliterated; that the trochanter has subsided nearly to a level with the articular head; and that the trochlea is circumscribed by two equal-sized lips.

The femur of the *Camel* more nearly resembles that of Man. It is long, slender, and curved backwards. The body is prismatic in its middle portion, and the two branches of the *linea aspera* meet in the middle and diverge towards the ends. The articular head is very much separated from the trochanter major, which is below the level of the most prominent part of the head. The internal condyle is smaller than the external, and the trochlea is narrow, while its lips are equal.

B. **Pig.**—In the femur of the *Pig*, there is also noticed a supra-condyloid fossa, but it is wide and shallow; the rugosities of the posterior face are replaced by some salient lines; the trochanter major is on a level with the head; the latter is supported by a somewhat constricted neck, and is situated within, and in front of, the trochanter major. This latter disposition changes the direction of the great axis of the superior extremity, which obliquely crosses that of the inferior extremity.

Fig. 92.



FEMUR OF THE CAT AND RABBIT.

A, Femur of the Rabbit. B, Femur of the Cat. 1, Diaphysis; 2, head; 3, internal trochanter; 4, trochanter major; 5, subtrochanteric crest; 6, trochlea; 7, internal condyle; 8, sesamoid imbedded in the internal ligament of the femoro-tibial articulation.

C. **Carnivora.**—In the *Dog* and *Cat*, the femur is long and curved like a bow. The rugged surfaces of the posterior face are confounded, and form two crests representing the *linea aspera* of the human femur. These crests do not lie against each other in the middle portion of the bone—they are merely parallel; then they diverge above and below, to terminate beneath the great and small trochanters, and above the two condyles. The trochanter major is not so high as the particular head. The femur of Carnivora is also distinguished: 1. By the complete absence of the third trochanter and the supra-condyloid fossa—this last being replaced by a small tubercle, which terminates below the external branch of the *linea aspera*. 2. By the marked constriction and length of the neck supporting the articular head. 3. By the depth of the digital fossa.

In the Cat and Rabbit are found small bony nodules, embedded like sesamoids in the substance of the lateral ligaments of the femoro-tibial articulation. After maceration, they often adhere to the condyles of the femur.

D. **Rodents.**—The femur of the *Rabbit* resembles that of the Dog. It is flat before and behind, and more bent inwards at its upper end. The internal trochanter appears as a crest, and not a tubercle; and the subtrochanteric crest is very developed, and placed immediately below the trochanter major.

Leg.

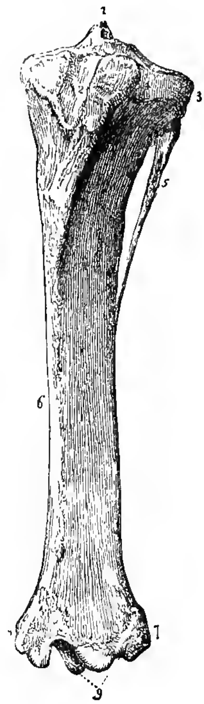
This has for its base three bones: the *tibia*, *peroneus* (or *fibula*), and the *rotula* (or *patella*).

1. Tibia (Fig. 93).

The *tibia* is a long prismatic bone, thicker at the superior than the opposite extremity, and situated between the femur and the astragalus, in an oblique direction downwards and backwards, constituting the principal portion of the leg. It has a *body* or *shaft*, and *two extremities*.

Body.—This offers for study *three faces* and *three borders*. The *faces* are wider above than below. The *external* is almost smooth, and is concave in its superior part and convex below, where it deviates to become the anterior. The *internal*, slightly convex on both sides, presents, superiorly, deep imprints for the attachment of the adductor muscles of the thigh and the semitendinosus. The *posterior*, nearly plane, is divided into two triangular surfaces: one, superior, slightly roughened, serves for the attachment of the popliteus muscle; the other inferior, much more extensive, is furrowed into numerous longitudinal crests, which give attachment to the perforans muscle. On the limit of these two surfaces is remarked the nutrient foramen of the bone. The *borders* are distinguished as *anterior*, *external*, and *internal*. The *first* is rounded, and not very salient in its inferior two-thirds; it forms, in its superior third, a curved crest, with the concavity external, which joins the anterior and superior tuberosity of the bone; this has received the name of the *tibial crest*. The *external border* is very thick and concave above, where it constitutes, in common with the fibula, the *tibial arch*. The *internal* is also very thick, straight, and provided superiorly with some salient tubercles to which the popliteus is attached.

Fig. 93.



POSTERIOR VIEW OF RIGHT TIBIA.

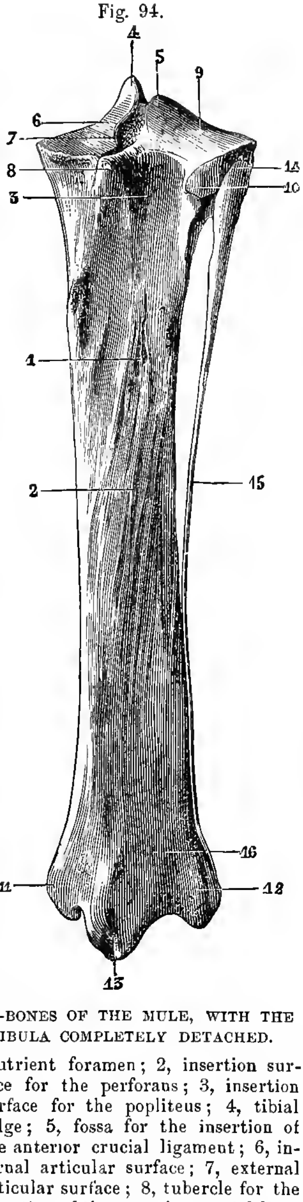
1, Tibial spine; 2, fossa for the insertion of the internal meniscus; 3, external tuberosity with articulation for the fibula; 4, fossa for the insertion of external meniscus; 5, fibula, forming with the tibia the tibial arch; 6, shaft, or body of the tibia; 7, 8, external and internal malleoli, inferior tuberosities, or lateral processes of the tibia; 9, articular trochleæ with a median ridge, for articulation with the astragalus.

Extremities.—The *superior extremity*, the most voluminous, is formed by three tuberosities—an anterior and two lateral, which are external and internal. The *first*, the smallest, is a rugged process continuous with the tibial crest, and separated from the external tuberosity by a wide and deep groove, into which passes a tendinous cord; it is excavated, in front, by a vertically elongated fossa, which lodges the middle ligament of the patella. The *external tuberosity*, medium in size and the most detached, has outwardly an articular facet for the head of the fibula. The *internal tuberosity*, the largest and least detached, presents: on the sides, ligamentous imprints; behind, a small tubercle which gives attachment to the posterior crucial ligament of the femoro-tibial articulation. The superior face of the two lateral tuberosities is occupied by two large, irregular, and undulated articular surfaces, which respond to the condyles of the femur, through the medium of the two meniscus-shaped fibro-cartilages interposed between the two bones. Of these two surfaces, the external is always the widest, because it serves, by its posterior part, for the gliding movements of the popliteal tendon. They are separated from each other by the *tibial spine*—a conical articular eminence, divided into two lateral parts by a groove for insertion excavated at its base; and in front by two lateral facets for the insertion, anteriorly, of the two inter-articular cartilages; it is bordered behind by another fossa, which receives the posterior insertion of the internal meniscus.

The *inferior extremity*, flattened behind and before, exhibits an articular surface moulded on the pulley of the astragalus, and two lateral tuberosities. The *articular surface* is formed by two deep cavities, oblique forwards and outwards, and separated by a median tenon which terminates posteriorly by a very prominent projection, on which the bone rests when it is made to stand vertically on a horizontal plane. The *external tuberosity*[1] projects but little, and is traversed in its

[1] The *external malleolus* of Man

Fig. 94.



LEG-BONES OF THE MULE, WITH THE FIBULA COMPLETELY DETACHED.

1, Nutrient foramen; 2, insertion surface for the perforans; 3, insertion surface for the popliteus; 4, tibial ridge; 5, fossa for the insertion of the anterior crucial ligament; 6, internal articular surface; 7, external articular surface; 8, tubercle for the insertion of the posterior crucial ligament; 9, fossa for the insertion of the internal meniscus; 10, tibial crest; 11, internal and inferior tuberosity; 12, external and inferior fissure of the tuberosity; 13, posterior prominence formed behind by the median spur of the inferior articular surface; 14, superior extremity of the fibula articulating with the tibia; 15, the body of the fibula—completely developed in this specimen.

middle by a vertical fissure. The *internal tuberosity*,[1] better defined, is margined posteriorly by an oblique channel.

Structure and development.—The tibia is very compact in its inferior portion, and is developed from five chief centres of ossification. The body is formed by one and the superior extremity by two, the anterior tuberosity having one of these; the last develops the whole of the inferior extremity of the bone, except the external tuberosity, which is developed from a separate nucleus, that at an early period becomes fused with the principal one of the epiphysis.

The tibia of the **Ass** is remarkable for the more or less perfect equality of the prominences around the inferior articular surface, so that this bone can sometimes lie in stable equilibrium on its inferior extremity. It is also distinguished from that of the Horse by: 1. The more or less marked obliquity of the grooves which articulate with the astragalus. 2. The disposition of the oblique prominence coursing the surface, for the insertion of the popliteus muscle. 3. The great development of the imprint for the semitendinosus muscle, and the crest above the groove for the oblique flexor tendon of the phalanges.

The tibia of the **Mule** and **Hinny** more particularly resembles that of the Horse.

2. Fibula, or Peroneus (Fig. 94).

A small, undeveloped bone, elongated and styloid in shape, situated outside the tibia, and extending from the superior extremity of that bone to the middle or lower third of its body.

The *middle portion* of the fibula is thin and cylindrical, and forms above, in common with the external border of the larger bone, the *tibial arch*. Its *superior extremity*, wide and flattened on both sides, has received the name of *head*. It offers, on its internal face, a diarthrodial facet to articulate with the external and superior tuberosity of the tibia; on its external face it shows ligamentous imprints. The *inferior extremity* of the fibula

[1] The *internal malleolus*.

terminates in a blunt point, and gives attachment to the ligamentous fibres that unite it to the tibia.

The fibula is sometimes continued to the external inferior tuberosity of the latter bone, with which it is confounded; and as this tuberosity always forms a special nucleus, particularly in the young Foal, it seems natural, having regard to the disposition observed in Pachyderms and the Carnivora, to consider it as the inferior extremity of the fibula fused to the tibia. In these animals, indeed, the tuberosity or external maleolus is formed by the inferior extremity of the fibula.

Structure and development.—This bone is very compact, and apparently developed by a single nucleus of ossification; though, in reality, there are two, one of which is for the head of the bone.

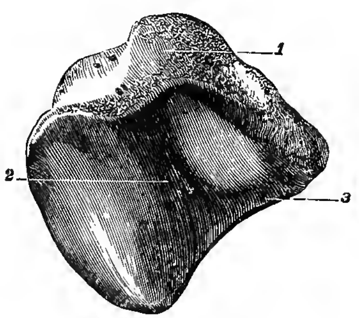
3. Patella (Figs. 95, 96).

A small, short, and very compact bone, situated in front of the femoral trochlea, and annexed to the tibia, to which it is attached by three extremely solid ligamentous bands.

The small polyhedron which it represents only offers for study three faces:

Fig. 95.

A

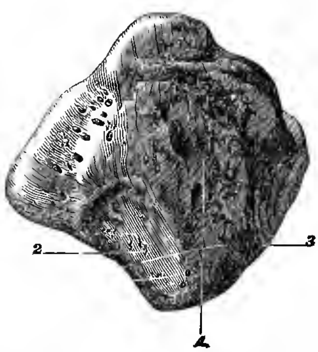


PATELLA OF THE HORSE (SUPERIOR AND POSTERIOR FACES).

1, Superior face; 2, posterior articular face; 3, external border.

Fig. 96.

B



PATELLA OF THE HORSE (ANTERIOR FACE).

1, Anterior face; 2, external border; 3, internal border.

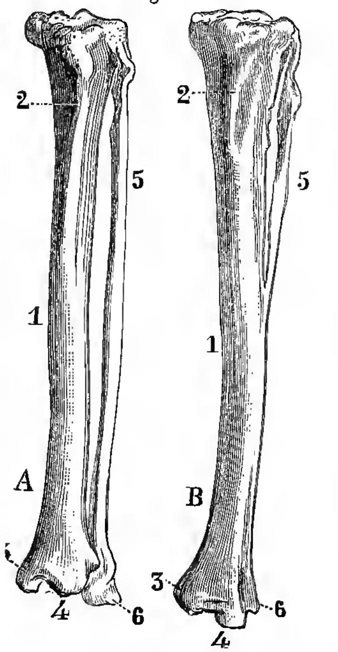
the *superior*, roughened, and serving for the insertion of the triceps cruralis and rectus muscles; the *anterior*, convex and irregular; and the third, the *posterior*, moulded on the femoral trochlea, to which it is but imperfectly adapted. In the fresh state, however, the articular surface formed by the latter face is completed by a fibro-cartilaginous apparatus, which will be noticed when describing the femoro-tibial articulation. This articular surface is composed: 1. Of a median ridge, which occupies the bottom of the trochlear cavity. 2. Of two depressed, gliding, lateral facets on the sides of this cavity; the internal facet is always larger than the external—a disposition which permits the patella of one limb to be distinguished from that of the other.

The Patella of the **Ass** is usually narrower than that of the Horse, but this feature would scarcely permit of its being distinguished from that of the other domestic Equidæ.

Differential Characters in the Leg-bones of the other Animals.

In the leg-bones there is observed, in the various domesticated animals, differences analogous to those mentioned as existing in the *forearm* of the pectoral limb. More particularly is this the case with regard to the development of the *fibula*. The relations existing between the development of that bone and the number of digits, is less marked than that which exists between the development of the ulna and the division of the digital region. Thus, in Ruminants the fibula is only represented by its inferior nucleus of ossification, although there are two apparent and free digits. In these animals the patella is also very narrow; and in all the domesticated species except Solipeds, the articular grooves in the lower end of the tibia are directed immediately from before to behind.

Fig. 97.



LEG-BONES OF THE RABBIT AND CAT.

A, Bones of the Rabbit. B, Bones of the Cat. 1, Diaphysis of the tibia; 2, crest of the tibia; 3, internal malleolus or tuberosity of the inferior extremity of the tibia; 4, anterior extremity of the median tenon on the inferior articular surface of the tibia; 5, fibula; 6, external malleolus or tuberosity.

A. **Ox, Sheep, Goat.**—In the *Ox*, the tibia is short; it is longer in the *Goat* and the *Sheep*. The *tibia* of these animals is remarkable for: 1. The absence of the lateral facet on the supero-external tuberosity. 2. The absence of a vertical fossa on the anterior tuberosity. 3. The absence of roughened lines on the posterior face. 4. The obliquity downwards and inwards of the inferior articular surface. The most salient point of this surface is the anterior extremity of the middle tenon.

The body of the *fibula* and its upper extremity are replaced by a fibrous cord, which is sometimes ossified wholly or in part, and may then resemble the fibula of Solipeds. The inferior extremity forms a small isolated bone (the *tarsal coronoid bone* of some authorities), articulating in one direction with the tibia, and in another with the calcis and astragalus.

B. **Camel.**—The tibia of the *Camel* is very long, slightly bent outwards at its upper end, and inwards at the lower end. The tibial crest is high and sharp. The posterior face shows only one roughened line limiting the popliteal surface.

C. **Pig.**—In the *Pig*, the fibula is flattened on both sides, extends the whole length of the leg, and is united to the tibia by its two extremities: above, by a diarthrodial facet; below, by an interosseous ligament. It is developed from three ossifying centres; the inferior articulates with the calcis and astragalus.

D. **Dog, Cat.**—In *Carnivora*, the tibia is long and slender, and presents a salient anterior crest. The fibula is also as long as the tibia, and is united to that bone at three points: at the two extremities by articular surfaces, in the inferior third and middle by an interosseous ligament.

E. **Rabbit.**—The leg-bones of this animal much resemble those of Carnivora, differing only in: 1. More pronounced flattening of the tibia on each side at its upper end, and before and behind inferiorly. 2. The slightly salient malleoli. 3. The fibula, which is fused with the tibia in its lower third.

Posterior Foot.

This region, which bears the greatest resemblance to the same region in the anterior limb, comprises three subdivisions—the *tarsus*, the *metatarsus*, and the *digital region*.

1. Bones of the Tarsus (Figs. 98, 99).

These are short, very compact bones, six or seven in number, and situated between the inferior extremity of the tibia and the superior extremity of the metatarsal bones ; they are arranged, like the bones of the carpus, in two tiers—a superior and an inferior.

The superior row only comprises two bones, the largest ; these are the *astragalus* and the *calcaneum* (or *calcis*). The inferior row is formed, outwardly, of the cuboides alone ; inwardly and anteriorly, it is subdivided into two secondary rows, the superior of which is constituted by the *scaphoides*, and the inferior by the *large* and *small cuneiform* bones. The last is sometimes divided into two, in which case there are three cuneiforms ; then the total number of the bones is seven.

Fig. 98.

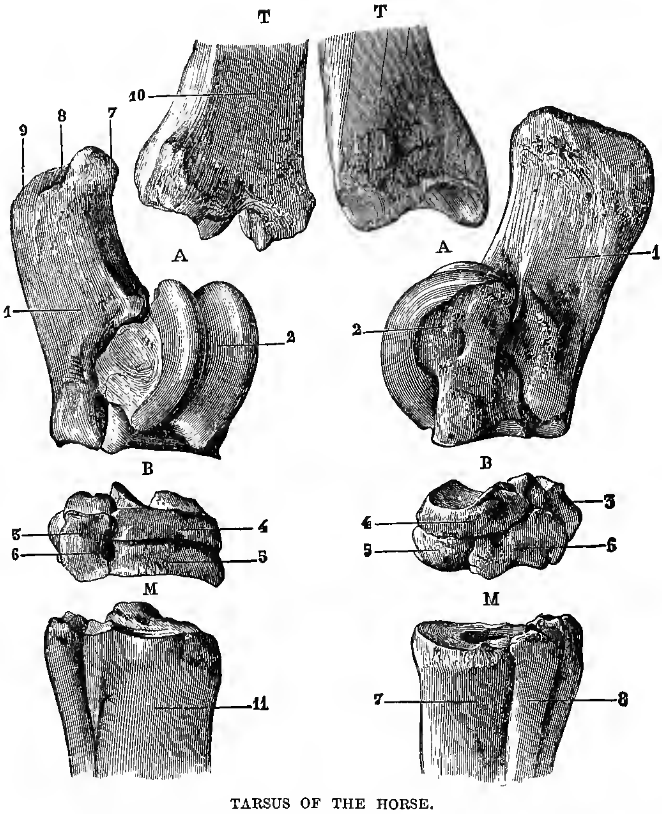
LEFT HIND FOOT (EXTERNAL ASPECT).

1, Tibia ; 2, summit of calcis or calcaneum ; 3, astragalus ; 4, cuboid ; 5, scaphoid ; 6, cuneiform magnum ; 7, large metatarsal bone ; 8, small metatarsal bone ; 9, suffraginis, proximal, or first phalanx ; 10, sesamoid bones ; 11, coronary, second, or middle phalanx ; 12, pedal bone, or third or distal phalanx ; 14, navicular bone ; 15, basilar process of pedal bone.

Astragalus.—An irregular cubical bone, situated in front of the calcis, between the tibia and the scaphoid, and divided into *five faces :* 1. A *superior* and *anterior*, formed as an articular pulley to correspond with the inferior extremity of the tibia. This pulley—oblique from above downwards, forwards, and outwards—may be considered as the type of the most perfect trochlea in the body ; it forms with the median plane of the body an angle of from 12° to 15°. Its borders are slightly spiral, the inner being more prolonged backwards than the external ; its groove receives the median tenon of the tibia, and its two ridges or lips fit into the lateral furrows of that bone ; the two lips are deeply implanted in the lateral grooves, and their two fossæ are hollowed out of their lower extremity, to admit the end of the principal bone during flexion movements. 2. An *inferior face*, occupied by a slightly convex articular surface articulating with the scaphoid ; this surface is notched outwardly by an excavation for ligamentous insertion ; behind the internal extremity of this furrow, the articular face is cut in such a manner as to present two facets inclined towards each other, and separated by a sharp ridge. 3. A *posterior face*, irregular, cut into three or four diarthrodial facets adapted for similar facets on the calcis, and which are separated by a wide, rugged excavation ; the middle facet is elliptical, almost vertical, slightly convex, and is the largest. 4. An *external face*, covered with imprints for the tibo-tarsal ligaments. 5. An *internal face*, provided below with a small tubercle for insertion, and, posteriorly, with a badly defined sinuous furrow for the tendon of the oblique flexor muscle of the phalanges (Fig. 99).

Calcaneum, or *Calcis* (Figs. 98, 99, 100, 101).—A bone vertically elongated, flattened on both sides, and presenting *two faces*, *two borders*, and *two extremities*. The *external face* is smooth and nearly plane. The *internal face* is excavated into a gliding groove to form the *tarsal groove*, in which passes the tendon of the perforans. The *anterior border* is slightly concave. The *posterior border* is

Fig. 99.



TARSUS OF THE HORSE.

INTERNAL ASPECT.

1, Calcis; 2, astragalus (first and second bones of the upper row); 3, cuboid; 4, scaphoid; 5, cuneiform magnum; 6, vascular canal between the cuboid, scaphoid, and cuneiform magnum; 7, smooth surface for the tendon of the gastrocnemius; 8, surface for insertion of latter; 9, smooth surface for the tendon of the perforans; 10, anterior extremity of the tibia; 11, superior extremity of the large metatarsal bone. A, Bones of the upper row. B, Bones of the lower row. T, Tibia. M, Metatarsus.

ANTERO-EXTERNAL ASPECT.

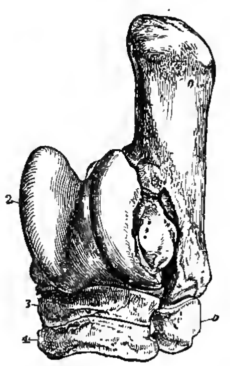
1, Calcis; 2, astragalus; 3, cuneiform magnum; 4, scaphoid; 5, cuboid; 6, cuneiform parvum; 7, superior extremity of large metatarsal bone; 8, superior extremity of inner small metatarsal bone. A, Bones of the upper row. B, Bones of the lower row. T, Tibia. M, Metatarsus.

thicker, straight, and rugged. The *superior extremity*, slightly enlarged, constitutes the summit of the calcaneum, and is divided into three parts : a middle, which gives attachment to the tendon of the gastrocnemius ; the other, the anterior, is a smooth surface on which this tendon rests when the foot is much flexed ; the third, altogether posterior, also constitutes a gliding surface for the tendon of the perforatus. The *inferior extremity*, wide and voluminous, shows in front three or four articular facets which articulate with the astragalus, and are separated, like those of the last bone, by an irregular and slightly excavated surface for insertion. Below, it shows for articulation with the cuboid a fifth facet, continuous with one of the preceding.

Development.—The calcaneum is developed from two nuclei of ossification, one of which is for the summit.

Cuboid bone (Figs. 98, 99).—This little bone, situated at the external side of the scaphoid and the large cuneiform bone, between the calcis and two of the metatarsals, does not resemble a cube, but a parellelopiped elongated from before to behind. It offers *six faces :* a *superior*, an articular face, in contact with the calcaneum ; an *inferior*, also articular, articulating with the principal and external rudimentary metatarsal bones ; an *internal*, furnished with three facets for contact with the scaphoid and great cuneiform, and crossed from before to behind by a fissure,

Fig. 100.



LEFT HOCK (FRONT VIEW).

1, Apex of calcaneum ; 2, astragalus, inner ridge ; 3, cuneiform magnum ; cuneiform medium ; 5, cuboid.

Fig. 101.

LEFT HOCK (INTERNAL ASPECT).

1, Apex of calcaneum ; 2, inner articular ride of astragalus ; 3, navicular, scaphoid, or cuneiform medium ; 4, cuneiform magnum ; 5, cuboid ; 6, cuneiform parvum.

which forms with these two bones a vascular canal ; an *external*, an *anterior*, and a *posterior*, covered with imprints.

Scaphoid bone (the *large cuneiform* of Percivall) (Figs. 98, 99).—Flattened above and below, it is described as having *two faces* and a *circumference.* The *faces*, both articular, are furrowed by a channel of insertion, and are distinguished as *superior* and *inferior*. The first is concave, and articulates with the astragalus ; the second is convex, and in contact with the two cuneiform bones. The *circumference* offers, outwardly, two small facets, which are adapted to similar facets on the cuboid bone. For the remainder of its extent, it is covered with imprints (Fig. 99).

Great Cuneiform bone (the *middle cuneiform* of Percivall) (Figs. 99, 100, 101).—Flattened above and below, and triangular in shape, this bone is much smaller than the scaphoid, though resembling it in a striking manner. Its *superior face* is in contact with the latter bone, and its *inferior face* articulates with the middle and internal lateral metatarsal bones. Its *external border* is provided with one or two facets to correspond with the cuboid bone ; and its *internal border* also shows one, which is in contact with another on the small cuneiform. Its *anterior border* is roughened throughout its extent (Figs. 99, 100).

Small Cuneiform bone (Figs. 99, 101).—Situated at the inner side of the tarsus, this bone—the smallest of any yet examined—is elongated from before to behind, flattened on both sides, and wedged in between the os scaphoides, the large cuneiform bone, and the large and internal small rudimentary metatarsal bones, with which it corresponds by four articular facets : a superior, two inferior, and one internal. When this bone is in two portions, there are then three cuneiforms, which may be distinguished, as in Man, by naming them *first*, *second*, and *third* (Fig. 99).

It is not very rare to find the scaphoid (*cuneiform magnum*) fused with the great cuneiform (*cuneiform medium*), and sometimes even the cuboid is joined to the cunean bones.

Development.—All the bones of the tarsus, with the exception of the calcis, are developed from a single nucleus of ossification.

The astragalus in the **Ass** is distinguished from that of the Horse by the external lip of the trochlea, which is abruptly deviated outwards at its inferior extremity ; and by the disposition of the inferior articular surface, which is regularly convex from side to side, behind the groove for insertion ; in the Horse this part of the articular surface is formed by the union of two facets inclined towards each other. In the same animal, the scaphoid (*cuneiform magnum*) is recognized by the shape of the superior diarthrodial surface, which is a hollowed reproduction of the inferior face of the astragalus ; and the *great cuneiform* (*cuneiform medium*) by the larger concavity of its scaphoid face.

Differential Characters in the Tarsal Bones of the other Animals.

In the domestic animals, the tarsus differs in the number and shape of the bones entering into its formation.

A. **Ox, Sheep, Goat.**—The tarsus of these animals is slender, and has only five bones, the cuboid and scaphoid being fused into one. The astragalus is elongated from above to below, and is united to the scaphoid by an antero-posterior groove, and to the calcis by a vertical groove; so that it has three trochleas. The principal trochlea has its external border thicker than the internal, and decreases from below to above. The posterior trochlea is not so deep as the others. The calcis is long and thin; the posterior gliding surface on the summit is excavated into a channel. The *small cuneiform* is pisiform, and but slightly developed.

B. **Camel.**—In the Camel, there are six tarsal bones, two of which are cuneiform. The *astragalus* articulates, by means of a double groove, with the scaphoid and cuboid. The *calcis* is relatively short, and about equally excavated on its two faces. The cuboid is voluminous.

C. **Pig.**—The tarsus of this animal much resembles that of Ruminants in its general disposition, and in the astragalus and calcis; but it has seven bones, because the *cuboid* and *scaphoid* are separate, and there are constantly three *cuneiform* bones.

D. **Dog, Cat.**—There are seven bones in the tarsus of these animals. The *astragalus* articulates with the scaphoid—almost as in Man—by means of a true head, separated from the rest of the bone by a constriction named the *neck of the astragalus*. The *cuboid* and the three cuneiform bones articulate with the five metatarsal bones.

2. Bones of the Metatarsus (Figs. 98, 102).

These bones are three in number—a median and two lateral—and offer the greatest analogy to the metacarpal bones. This enables us to dispense with a general description of them, and to confine ourselves only to indicating the differential characters which distinguish them from the corresponding bones in the anterior limb.

The *principal*, *large*, or *median* metatarsal bone, is longer than the same metacarpal, and its body, instead of being slightly compressed before and behind, is nearly a regular cylinder. It presents, outwardly, a fissure which is directed at first obliquely backwards and downwards (Fig. 99), and afterwards descends vertically along the lateral external metatarsal bone. The articular surface of the superior extremity is excavated in its centre by a large fossa for insertion (Fig. 99). This surface presents, behind and outwards, a thick tubercle which appears to spring from the body of the bone, and which has a facet against which the external rudimentary metatarsal rests. The inferior extremity is at the same time wider and thicker than that of the metacarpus. Above and in front of the articular surface, it is hollowed by a small transverse fossa, which is deeper than in the corresponding bone in the anterior limb.

Of the *two rudimentary* (*digital*, *splint*), *or lateral metatarsal bones*, the external is always longest, if not thickest. The internal bears on the superior face of its head three articular facets, two of which articulate with the small cuneiform, and the third with the large bone of that name.

The length of these rudimentary metatarsals is nearly equal to three-fourths that of the principal metatarsal.

The metatarsus of the **Ass** is remarkable for the length of its rudimentary metatarsals, which are nearly five-sixths that of the principal bone. The latter is also notable, because of its length and fineness; and if it is compared with that of the Horse, it is distinguished by: 1. The triangular shape of its upper extremity, due to the great development of the tubercle on which the external rudimentary metatarsal lies. 2. The flat diarthrodial facet which articulates with the antero-external part of the large cuneiform. 3. The marked inequality of its condyles.

Fig. 102.

POSTERIOR ASPECT OF LEFT METATARSUS.

1, Head of principal metatarsal bone; 2, 3, external and internal splint bones, or metatarsals of the rudimentary digits; 4, rough surface for insertion of suspensory ligament; 5, nutrient foramen; 6, middle ridge or tenon of inferior articular surface.

Differential Characters in the Metatarsal Bones of the other Animals.

The metatarsus is also a region in which the number of bones varies in the domesticated animals. Thus, in *Ruminants* there are two, and five in the *Pig*, *Carnivora*, and *Rodents*.

The metatarsals of the latter are exactly like the same bones in the anterior limb. Those of Ruminants are slightly different.

A. **Ox, Sheep, Goat.**—In the *Ox*, *Sheep*, and *Goat* are found a principal and a rudimentary metatarsal bone. The latter is a small lenticular bone, articulating, posteriorly, with the head of the large metatarsal bone. The latter differs from the principal metacarpal bone, in being longer, quadrilateral in form, and having a vascular canal traversing the posterior face of its upper extremity.

B. **Camel.**—The metatarsus differs from the metacarpus by its greater width and less thickness; the articular surface is divided by a depression into two parts, situated on the same horizontal plane.

C. **Pig.**—The *Pig* has four perfect metatarsals, and an internal rudimentary one. The latter is a small bone flattened on both sides, articulating by means of a diarthrodial facet, and sometimes fused posteriorly with the upper end of the fourth metatarsal.

D. **Dog, Cat.**—In the *Dog* and *Cat* are one rudimentary and four perfect metatarsals. The former is articulated with the internal cuneiform, and represents the vestige of the thumb.

3. Bones of the Digital Region (Fig. 98).

In Man, the digits of the foot—known as *toes*—are very different to those of the hand; but it is otherwise with the domestic animals. The phalangeal region of the posterior, closely resembles that of the anterior limb. The analogy in the conformation of these bones is even pushed so far, that it becomes very difficult to distinguish them from one another.

There are some differential characters, however. For instance, it is remarked: 1. That the first phalanx is not so long as in the anterior limb, and less wide and thick at its inferior extremity; but it is, on the contrary, wider and thicker at its superior extremity. 2. That the lateral diameter of the second phalanx is shorter. 3. That the third phalanx, less expanded towards its inferior border, has more the shape of a V, and that its inferior face is more concave. 4. That the sesamoids are less voluminous. 5. That the navicular bone is shorter and narrower.

In the **Ass**, the same differential features are observed between the posterior and anterior phalanges as in the Horse, and there are no very marked differences between the former in these two animals. The following may, however, serve to distinguish them.

The *first* phalanx of the Ass is proportionately longer than that of the Horse, and the rugosities are larger; the principal nutrient foramen is usually on the anterior face, and the external glenoid cavity is much smaller than the internal.

The *second* phalanx is also proportionately longer than that of the Horse. Its inferior median furrow is deep, especially behind; it has generally numerous nutrient foramina below the posterior gliding surface; the median tenon of its upper face terminates before and behind by a salient tubercle, which prevents the bone from resting in equilibrium when it is placed vertically on that face.

The *third phalanx* of the Ass is higher than that of the Horse, owing to the development of the pyramidal process; it is constricted above the preplantar fissure; the surface of the sole is proportionately more extensive, and the concavity of the semilunar crest is less marked; the extremities of that crest are salient, aud the plautar fissures very deep.

The *navicular bone* shows very marked differences. In the Ass its thickness is very considerable, due to the median ridges on both faces. Its posterior border is very oblique downwards and backwards, and it is towards this border that it inclines when we attempt to make it lie horizontally on its upper face; while its two extremities are more curved than in the Horse.

In the **Mule** and **Hinny**, the two first phalanges much resemble those of the Ass, while the third shows the characters of that of their progenitors. Nevertheless, that of the Hinny is rather more like the third phalanx of the Horse than that of the Ass, while the contrary is observed in that of the Mule.

Differential Characters in the Posterior Phalangeal Region of other Animals.

In all the domesticated animals, the posterior digits comport themselves exactly like the anterior. The *Carnivora* alone offer a notable difference; in them, in reality, the inner toe, the equivalent of the thumb, does not exist—or rather, it is only represented by the rudimentary metatarsal bone alluded to above. Nevertheless, it frequently occurs that a completely developed thumb is found in this animal; and in this case the rudimentary metatarsal is ordinarily followed by a ligamentous cord, to which is suspended a bony stylet that represents either the inferior extremity of the metatarsal bone, or the first phalanx; it is to this stylet that are found articulated in succession the second and third phalanges.

It is not rare to meet with a sixth floating toe in dogs of very large size.

Comparison of the Abdominal Limb of Man with that of Animals.

A. Pelvis (Fig. 103).—The longitudinal axis of the pelvis of *Man* forms, with the horizon, an angle of about 40°.

The bones which compose it are proportionately larger and stronger than in all the domesticated animals.

The two faces of the ilium, and especially the inner face, are much hollowed; the iliac crest has the form of an italic *S*.

The pubis alone participates in the formation of the pelvic symphysis, and the concavity which, in the domesticated animals, is called the ischial arch, is designated in Man the pubic arch.

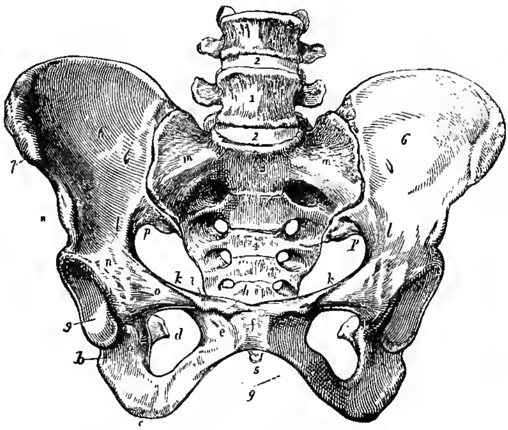
In consequence of the excavation on the inner face of the ilium, the pelvic cavity may be divided into the great and lesser pelvis. In the latter are lodged the genital and urinary organs, as well as the extremity of the digestive tube.

B. Thigh (Fig. 104).—The femur of Man is nearly vertical, and situated in a direction slightly oblique downwards and inwards; it presents a curvature forwards. The body of the bone is prismatic and triangular in its middle part; the posterior border of this prism forms a somewhat salient crest, which takes the place of all the insertion eminences on the posterior aspect of the femur in animals, and is designated the *linea aspera*. This line bifurcates above and below; below, the branches margin a triangular or *popliteal space.*

The head is supported by a long neck, inserted obliquely into the superior extremity. The two condyles are joined together in front by the trochlea, which is wide and shallow.

C. Leg (Fig. 105)—Three bones: the tibia, fibula, and patella.

Fig. 103.



HUMAN PELVIS (FEMALE).

1, Last lumbar vertebra; 2, 2, intervertebral substance; 3, promontory of the sacrum; 4, anterior surface of the sacrum; 5, coccyx; 6, iliac fossæ; 7, antero-superior spinous process; 8, antero-inferior spinous process; 9, acetabulum. *a*, Its notch; *b*, body of ischium; *c*, its tuberosity; *d*, its spine; *e*, pubis; *f*, symphysis pubis; *g*, arch of the pubes; *h*, angle of os pubis; *i*, spine of pubes, with crest between it and *h*; *k*, *k*, pectineal line; *l*, *l*, ilio-pectineal line, with its prolongation, *m*, *m*; *n*, ilio-pectineal eminence; o, smooth surface for femoral vessels; *p*, *p*, great sacro-ischiatic notch.

The *tibia* is very long; its crest (or spinous process) is much more developed than in any of the domesticated animals, and describes a kind of curve like an italic *S*. On the inner aspect of the inferior extremity is seen a voluminous process which occupies, inwardly, a portion of the tibio-tarsal articulation: this is the internal malleolus. The articular surface is not exactly formed to correspond with the whole articular surface of the astragalus.

The *fibula* is as long as the tibia. It is prismatic, and slightly twisted on itself. It articulates above and below with the tibia. The lower extremity responds to the astragalus, and forms a prominence named the external malleolus.

There is nothing particular to note in the patella.

D. Foot (Fig. 106).—The *foot* of Man is placed in a horizontal direction. Its upper aspect is convex; its inferior face is excavated, and it rests on the ground by its two extremities.

1. *Tarsus.*—In the *tarsus* there are seven bones, three of which are cuneiform. The astragalus articulates with the tibia and fibula; it responds to the scaphoid by a well-detached convex articular surface, named the head.

In the bones of the lower row, it is remarked that the cuboid responds to the fifth and fourth metatarsals; the first cuneiform to the third; the second cuneiform to the second metatarsal: and the third to the first.

2. *Metatarsus.*—The metatarsus is composed of five bony columns, nearly parallel to each

other. They are enumerated from without to within, and increase in length from the first to the fourth; the fifth is the shortest and most voluminous.

3. *Digital region.*—This comprises five digits or toes. The phalanges of these toes are analogous to those of the fingers, from which they are distinguished by their small size. They increase in volume from the first to the fifth digit.

Article VII.—The Foot in General.

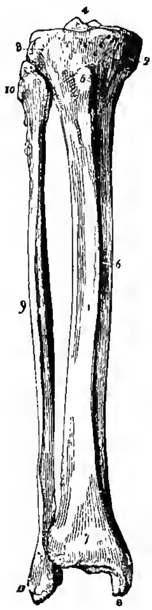
It would be useless to reproduce here the general considerations discussed when treating of the hand (p. 121), and it may therefore be sufficient to state

Fig. 104.

RIGHT HUMAN FEMUR (ANTERIOR ASPECT).

1, Shaft; 2, head; 3, neck; 4, great trochanter; 5, anterior intertrochanteric line; 6, lesser trochanter; 7, external condyle; 8, internal condyle; 9, tuberosity for attachment of external lateral ligament; 10, fossa for tendon of origin of popliteus muscle; 11, tuberosity for attachment of internal lateral ligament.

Fig. 105.



HUMAN TIBIA AND FIBULA OF RIGHT LEG (ANTERIOR ASPECT).

1, Shaft of tibia; 2, inner tuberosity; 3, outer tuberosity; 4, spinous process; 5, tubercle; 6, internal surface of shaft; 7, lower extremity of tibia; 8, internal malleolus; 9, shaft of fibula; 10, its upper extremity; 11, its lower extremity; between 1 and 6 is the sharp crest of the tibia.

Fig. 106.

DORSAL SURFACE OF LEFT HUMAN FOOT.

1, Astragalus; 2, its anterior extremity articulating with the cuboid bone, 4; 3, 3, calcis; 4, scaphoid; 5, internal cuneiform bone; 6, middle cuneiform bone; 7, external cuneiform bone; 8, cuboid bone; 9, metatarsal bones of first and second toes; 10, first phalanx of great toe; 11, second ditto; 12, 13, 14, phalanges of second toe.

that the works of the anatomists already mentioned—and especially those of Joly and Lavocat—have demonstrated that the foot of animals is constructed on the same type as the hand. In it, as in the hand, three sections are remarked: the *tarsus*, *metatarsus*, and *phalanges* ; and, in the archetype, each section comprises five parallel rows, each of which has two tarsal bones, one metatarsal, and three phalangeal. In the present fauna there is not, perhaps, a Mammal which has a perfectly typical pentadactylous abominal limb ; for this ideal disposition is modified in the sense already indicated for the hand. In the following brief paragraphs, an attempt will be made to show the manner in which Man and the domestic animals may be allotted to the archetype.

1. *Man.*—In Man the archetype is realized in the metatarsal and phalangeal sections, and it will now suffice to examine the tarsal section. This contains seven separate bones—three in the upper and four in the lower row. It must not be forgotten that the scaphoid, although situated between the two rows, nevertheless belongs to the upper, as happens in the carpus of certain species. Apparently, it is deficient in two bones in the upper row and one in the inferior. This deficiency arises from fusion of the apex of the calcaneum (*first superior metatarsal bone*) with the remainder of the bone (*second bone*), of the *scaphoid* with the *fifth bone* in the upper row, and of the *first inferior tarsal bone* with the cuboid in the second row.

2. *Carnivora.*—The foot of *Carnivora* only differs from that of Man in the arrangement of the thumb ; as this digit has usually no phalanges, and its metatarsal piece is only a small, very short styliform bone. Notwithstanding this difference, the pentadactylous archetype is as easily recognized in the foot of these animals as in that of Man.

3. *Rodents.*—The foot of the *Rabbit* and *Hare* is yet less complete than that of Carnivora, as the metatarsal of the thumb is absent ; but, by the constitution of the tarsus, *Rodents* resemble Carnivora and Man, and consequently they can be also classed in the pentadactylous type.

4. *Pig.*—In this animal, the tarsus presents the same number of pieces and the same fusions, as in Rodents, Carnivora, and Man. The metatarsus and phalangeal section have four complete toes—first, second, third, and fourth ; and with regard to the fifth digit, it is represented by a short, flat, and irregularly triangular metatarsal, articulating posteriorly with the third metatarsal, and attached to the third cuneiform by some ligamentous fibres.

5. *Ruminants.*—The foot of the *Ox*, *Sheep*, and *Goat* present numerous fusions, and even some abortions. The tarsus has only five distinct bones ; for, besides the fusions which exist as in the preceding animals, the *scaphoid* is united to the *cuboid*, and the *third cuneiform* is completely aborted.

The metatarsus of these animals includes a principal metatarsal, provided, inferiorly, with a double diarthrodial surface, and an internal rudimentary metatarsal. Must we consider the principal metatarsal as the result of the fusion of the third and fourth, and admit, in Ruminants, the abortion of the first two digits ? Several anatomists have professed this opinion. Lavocat did so at first, and then abandoned it. He considered the principal metatarsal as due to fusion of the metatarsals of the first four digits, and he expressed himself on this point as follows : " The first and the fourth metatarsals are visible, and fused above and behind the united large metatarsals. Each of them has the shape of a thick pyramid, with its base uppermost, large, and about five centimètres long in the *Ox*. Above, they join to form an arch, which is the contour of a wide and short vascular canal running between them and the two large metatarsals, and which does not exist in the *Goat* and *Sheep*. Their widened superior extremity is in contact with the bones of the tarsus, to wit : the first metatarsal with a facet of the *prototarsus*, or first portion of the cuboid ; the fourth metatarsal with all the inferior facet of the *tetrotarsus*, or second cuneiform. And each of them has, for this eminently normal connection, an articular facet well separated from the diarthrodial surface of the large metatarsals by a large fossa destitute of cartilage. In this way the first four metacarpals are gathered into a single bundle. . . . Lastly, the thumb, or fifth digit, is constantly represented in the foot by a distinct metatarsal bone—at least in the *Ox*, *Goat*, and *Sheep*."

Notwithstanding the reasons on which Lavocat bases his last interpretation as to the metatarsals of the Ox, we prefer adopting the first. In fact, if some wild Ruminants are examined—Deer, for example—there will be found a tarsus identical with that of the Ox, and a principal metatarsal provided with a vascular canal, with two inverted pyramidal expansions ; and, in addition, two styliform bones lying to the outside and the inside of the principal bone of the shank. These bones evidently represent the metatarsals of the second and fifth digits ; as they exist at the same time as the lateral ridges on the principal metatarsal bone, it appears to be impossible to give to the latter the same signification.

The posterior phalangeal region of the *Ox* is almost identical with the anterior ; it is, therefore, needless to again demonstrate its constitution. That of the *Sheep* and *Goat* has no rudimentary phalanges to serve as a base for the ergot, in the hand ; but the two ergots suffice to represent the first and fourth digits, and so to include these animals in the pentadactylous type.

6. *Solipeds.*—The tarsus of these animals has six or seven bones. In the second case, it is identical with that of Carnivora and Man ; in the first, the second and third cuneiforms are fused. The metatarsus and posterior phalangeal section having the same constitution as those of the anterior, the reader is referred to the description of the Hand in General.

Article VIII.—The Limbs in General and their Parallelism.

A. The Limbs in General.—The bony sections which compose the limbs, are destined not only to support the trunk in a stationary attitude, but also to transport it during progression. This double use gives rise to a difference between the anterior and the posterior members. The front limbs, being nearer the centre of gravity than those behind, have to sustain the largest share of the weight. They ought, consequently, to be specially organized as organs of support. Therefore it is, that the four principal bones composing each of them—shoulder, arm, forearm, foot—although flexed, or disposed to be flexed, in an inverse sense to one another, oppose to the pressure of the weight of the trunk—which tends incessantly to throw them down—obstacles purely mechanical, and of such energy that we may still understand how the body can be sustained on the anterior limbs, if we suppose all the muscular masses surrounding these bony columns to be removed, except one.

Thus, the weight of the body is transmitted to the scapula through the muscles that attach that bone to the trunk. It then passes to the humerus, and thence to the radius, to be thrown, finally, on the different pieces composing the foot. Now, the humerus forming with the scapula an angle which is open behind, and with the bones of the forearm another angle open in front, the weight of the body pressing continually on these angles tends to close them, and thus cause the flexion of these bones. But this result is prevented by the combined action of two muscular powers—the biceps and the extensors of the forearm. With regard to the radius, carpus, and metacarpus, owing to their vertical direction, they themselves support the pressure of the weight of the body without requiring any muscular aid. But the digital region, being directed obliquely forward and downward, forms, with the principal metacarpal, a third angle open in front, for the maintenance of which nature has given solid, inert, or contractile mechanical bands.

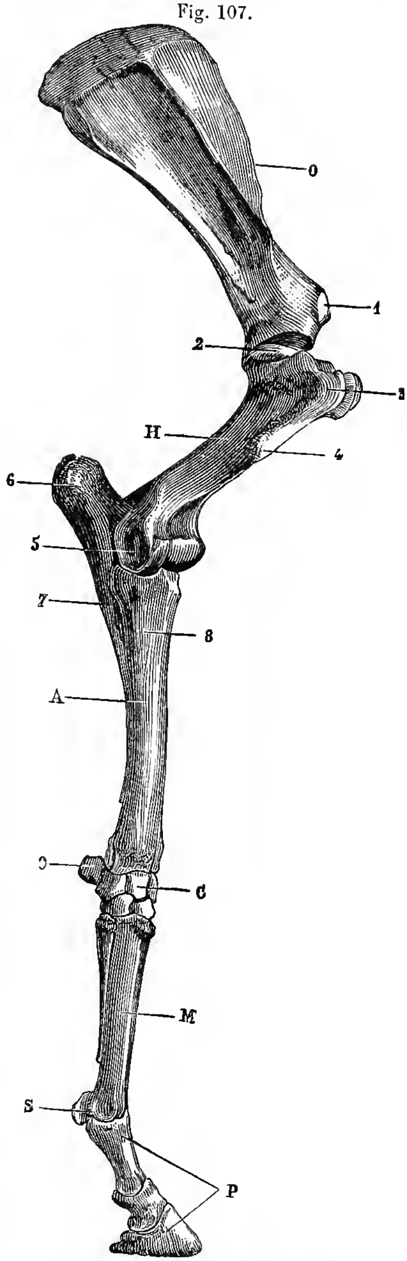
The anterior limbs are also agents of transport, for they can elevate the trunk by the spring of their bony rays, and fix themselves on the ground by their free extremities.

The posterior limbs are less favourably disposed than those in front to assume the function of columns of support; as their rays are, for the most part, in a state of permanent flexion, and joined in an angular manner to one another, as may be seen by glancing at the skeleton (Figs. 107, 108, 1, 2, 4, 5, 6). It is, therefore, necessary that muscular agency should prevent the breaking-down of these columns. Though defective as supports, they are nevertheless admirably designed to serve as agents of locomotion. The slightest erection of these inclined bones propels the mass of the body forward, and this impulsion is almost wholly transmitted to the trunk, in consequence of the very intimate union of the pelvis with the vertebral column.

B. Parallel between the Anterior and Posterior Limbs.—After what has just been said, it will be seen that the anterior limbs are more particularly destined for the support of the body, while the posterior ones more especially play the part of propelling agents in the locomotory acts.

Notwithstanding this difference in the functions assigned them, these two limits offer in their conformation such striking resemblances to each other, that some authors have been inclined to consider the posterior as an exact repetition of the anterior limb. The following is

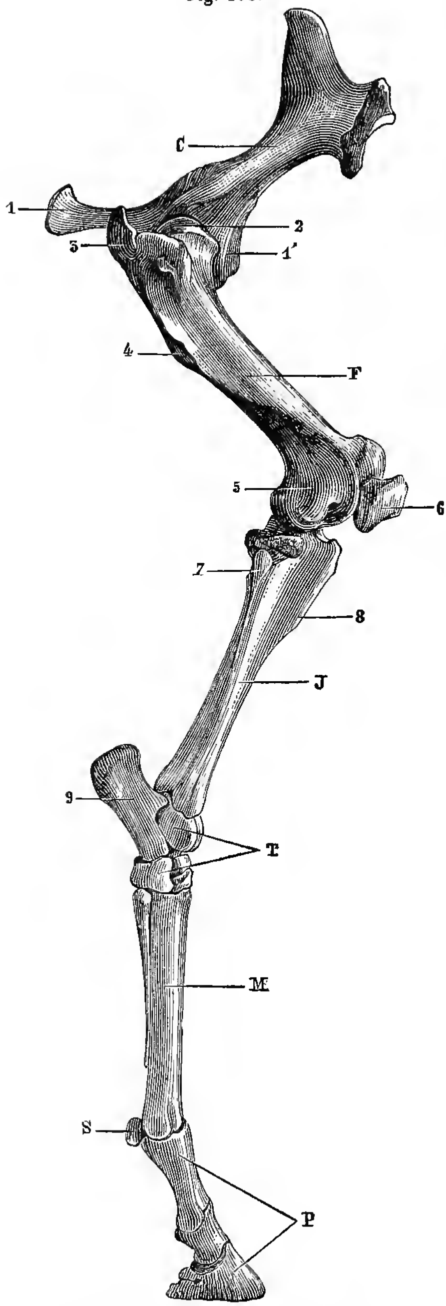
Fig. 107.



ANTERIOR LIMB OF THE HORSE (ANTERO-EXTERNAL VIEW).

O, Scapula; H, humerus; A, radius; C, carpus; M, metacarpus; P, phalanges; S, sesamoid bone. 1, Coracoid process; 2, head of the humerus; 3, external trochanter; 4, deltoid ridge; 5, inferior articular surface of the humerus; 6, olecranon; 7, ulna; 9, pisiform (trapezium), or supercarpal bone.

Fig. 108.



POSTERIOR LIMB OF THE HORSE (ANTERO-EXTERNAL VIEW).

C, Coxa; F, femur; J, tibia; S, tarsus; M, metatarsus; P, phalanges; S, sesamoid. 1, Ischium; 1′, pubis; 2, head of the femur; 3, trochanter major; 4, trochanter minor; 5, condyle of the femur; 6, patella; 7, fibula; tibial ridge; 9, calcis.

a brief analysis of the analogies existing between them.

At the end of the last century, Winslow and Vicq-d'Azyr, and nearer our own time, Cuvier, Flourens, Paul Gervais, Martins, Gegenbauer, Lavocat, Foltz, and Sabatier, have occupied themselves with the homology of the anterior and the posterior members. All these anatomists did not absolutely arrive at the same conclusion; for several of them, forgetting that the question should be examined in the whole animal series, made Man alone the subject of their studies.

Vicq-d'Azyr and Cuvier recommended that the anterior and posterior limbs of opposite sides should be compared. Martins and Gegenbauer, allowing a torsion of the humerus of 180°, advised that the two members of the same side should be compared, care being taken to make allowance for the untwisting of the 180° contortion at the lower end of the humerus. Lastly, Flourens and Lavocat contrasted the two members of the same pair with each other, after placing the hand in a position of natural pronation by rotation of the radius on the ulna, and without turning either limb or bone, or even a portion of a bone, no matter what kind of animal may be under examination. We will adopt the latter proceeding, as it is the simplest and most natural.

Parallel between the coxa and scapula.—The analogies existing between these two bones are but little striking at first sight; nevertheless, with attention there is no difficulty in finding in the coxa the three pieces that enter into the composition of the shoulder (Figs. 107, 108).

The ilium represents the scapula. The external iliac fossa reminds one of the supra- and subspinous fossæ. Occasionally, there is met with in the

Horse a rudiment of the crest dividing the iliac fossa into two parts, and in some animals—the Pig, Sheep, and Goat—this crest, which is the trace of the scapular spine, becomes constant and very evident.

With regard to the cotyloid cavity, it repeats in the posterior limb the glenoid cavity of the scapula. There remains to determine, in the latter bone, the portions analogous to the ischium and pubis. If we rely upon the evidence afforded by the muscular insertions, we come to the conclusion that the ischium corresponds to the coracoid process, and the pubis to the clavicle of animals which are provided with one. It will also be remarked that the coxa is directed backwards, while the scapula inclines obliquely forwards; this opposition in the direction of the bones in no way alters their analogies; the functions of the members to which they correspond require this inverse position.

Parallel between the femur and humerus.—The resemblance between these two bones is remarkable. Thus there is found in the first. 1. An articular head, better detached than that of the humerus, but shaped in the same manner. 2. A trochanter analogous to the great tuberosity, and also, like it, decomposable into three distinct parts—summit, crest, and convexity. 2. A lesser trochanter, representing the small tuberosity. 4. An eminence for the insertion of the superficial gluteus muscle, which takes the place of the deltoid imprint. 5. An inferior articular pulley continued between the two condyles by a non-articular groove; this trochlea certainly corresponds to the median groove of the inferior humeral face.

There are, no doubt, differences in the two bones, but they have no bearing upon the result just indicated. Thus, the linea aspera of the femur is situated behind; that of the humerus in front. In the femur the two condyles of the inferior extremity are placed behind the trochlea; the contrary holds in the humerus. These modifications are necessary, in order to give the movements of the limbs a convenient direction. The leg is flexed backward on the thigh, while the forear is flexed forward on the humerus.

Parallel between the bones of the leg and those of the forearm.—It is more particularly in these two regions that the question of analogies has been resolved in a contradictory manner by anatomists. It would have appeared less complicated had it been studied in a large number of species.

If we examine the leg-bones of certain *Marsupials*, in which the tibia and fibula are apart as in the radius and ulna in Man, it will be found that: 1. These two bones articulate with the condyles of the femur. 2. The anterior face of the tibia has no ridge. 3. The patella is attached to the upper end of the fibula. From this it might be concluded that, in Man and the domestic animals, the tibia, with the exception of its anterior and external tuberosities, is the homologue of the radius, and the fibula and external and anterior tuberosities of the tibia are the homologues of the body and inferior extremity of the ulna. The patella corresponds to the olecranon; the mobility of the first cannot be offered as an objection to this assimilation, for in Bactrians the olecranon forms, like the patella, an independent bony nucleus.

Parallel between the bones of the posterior and those of the anterior foot.—The analogy becomes so marked when these two regions are compared, that it is scarcely necessary to allude to them. The tarsal bones are to the posterior limb what the carpals are to the anterior one; it is even possible to compare, one by one, the several pieces in these regions. The metatarsals are but a repetition of the metacarpals; while the digital bones are so much alike, that it is difficult to distinguish the anterior from the posterior phalanges.

CHAPTER III.

THE BONES IN BIRDS.

THESE animals, destined for the most part to sustain themselves in the air, should exhibit in the conformation of their skeleton all the conditions which may favour aerial locomotion ; from this arise the differences which distinguish their skeleton from that of the Mammalia—differences which will now be rapidly traced.

VERTEBRAL COLUMN. *Cervical vertebræ.*—The cervical spine represents in the Bird, as in the Mammal, a kind of balancing-pole curved like an S, which supports the head, and by its changes in form and direction varies the centre of gravity. When a Bird rises in the air and flies rapidly, it lengthens the neck and stretches out the head, to carry the centre of gravity forwards. But when it rests on the ground, it makes the balancing-pole assume the natural and more or less graceful inflection, by throwing the head backwards, and transferring the greater portion of the weight of its body to the columns of support formed by the posterior limbs. These displacements of the centre of gravity are executed in Birds on a more extensive scale than in Mammalia ; the vertebral limbs in the former are also longer, lighter, and enjoy an excessive mobility.

The vertebræ composing it number fourteen in *Fowls*, twelve in the *Pigeon*, fifteen in the *Duck*, and eighteen in the *Goose ;* in the *Swan* twenty-three have been counted ;—a curious variety, which singularly contrasts with the numerical unity noticed as one of the most remarkable characters in Mammalia ! These vertebræ are generally longer than in the latter animals, and are particularly distinguished by the configuration of the articular surfaces of the inferior part or body. These are diarthrodial facets convex in one direction and concave in the other, articulating the vertebral bodies by a veritable and reciprocal clamping. In this manner, the anterior head of the body of each vertebra is replaced by a facet concave on both sides, and convex vertically ; while the posterior extremity of the bone bears, instead of a concavity, a facet convex in the lateral sense, and concave from above to below. The inferior crest of the body (Fig. 109, 2, 2′) only exists in the first and last vertebræ ; but it forms a veritable spine, analogous to that observed in the lumbar vertebræ of the Rabbit. The spinous process (Fig. 109, 1, 1′) only forms a simple crest in the middle part of the neck ; it becomes more salient in the vertebræ which occupy the two extremities of this region. The transverse process represents on the side of the vertebra a thick, obtuse, and irregular tubercle, situated under the anterior articular process, and pierced at its base by a large vertebral foramen (Fig. 109, 4, 4′). It is most frequently furnished with a small styloid prolongation (Fig. 109, 3, 3′) directed backwards and downwards, forming an epiphysis at an early period, and representing a real undeveloped rib.

The atlas has no transverse processes. This vertebra is shaped like a thin ring, and is excavated on its anterior contour by a small cavity, into which is received the single condyle of the occipital bone.

The axis shows a very marked odontoid process, with a single facet under that eminence.

Dorsal vertebræ (Fig. 109, B, C).—These are seven in the *Fowl* and *Pigeon*, and nine in the *Goose* and *Duck;* they are nearly always consolidated into a single piece to which the trunk is fixed, and which gives the wings a solid

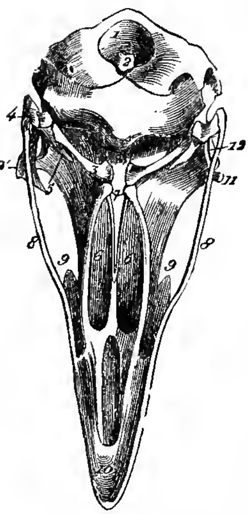
Fig. 109.

SKELETON OF A FOWL.

From A to B, *Cervical Vertebræ.* 1, spinous process of the third vertebra; 2, inferior ridge on body of the same; 3, styloid prolongation of the transverse process of the same; 4, vertebral foramen of the same; 1′, 2′, 3′, 4′, the same parts in the twelfth vertebra. From B to C, *Dorsal Vertebræ:* 6, spinous process of the first; 7, crest formed by the union of the other spinous processes. From D to E, *Coccygeal Vertebræ.* F, G, *Head:* 8, interorbital septum; 9, foramen of communication between the two orbits; 10, premaxillary bone; 10′, external openings of the nose; 11, maxilla;

support in the violent efforts that flight demands. The two or three last are often even covered by the wing-bones, and joined to them. The inferior crest of the body forms a very long spine, especially in the first vertebræ. The spinous processes—flat, wide, short, and consolidated with each other by their opposite borders—constitute a long crest extending from the last cervical vertebra to the bones of the wings (Fig. 109, 7). The transverse processes widen to their summit; in the *Fowl* they are nearly constantly fused with each other.

Fig. 110.



HEAD OF AN OWL (NATURAL SIZE; POSTERIOR VIEW).

1, Occipital foramen; 2, single occipital condyle; 3, pterygoid; 4, inferior articular surface of the os quadratum; 5, anterior process of ditto; 6, 6, anterior face of the palatine bones, forming the guttural orifice of the nasal cavities; 7, posterior extremity of ditto; 8, zygomatic; 9, lachrymal; 10, premaxilla; 11, orbital process; 12, right zygomatic process; 12′, zygomatic process on the opposite side, united to the orbital process.

Lumbar and sacral vertebræ.—All these vertebræ are formed exactly on the same type; so that it becomes difficult, if not impossible, to fix the point where the lumbar region ends or the sacral begins. At first independent of each other, these vertebræ, numbering fourteen, soon become consolidated with one another and with the ribs; but their primitive separation is always indicated by the lateral septa, which form, on their inferior face, the vestiges of the transverse processes. The former are closely united to the latter in the dorsal region.

Coccygeal vertebræ.—In the coccygeal region, the spine recovers its mobility. The tail of the Bird, indeed, fulfils the office of a rudder in directing it during flight; and it is absolutely necessary that the vertebræ which serve as a base for the steering feathers should preserve their independence, so as to allow these to be carried to the right, left, downwards, or upwards. These vertebræ—seven in number—present spinous processes which are often bifurcated, transverse processes very developed, and sometimes even spines more or less long on the inferior surface of their bodies. The last vertebra is always the most voluminous; it is flattened on both sides, and terminates in a curved-up point.

HEAD (Fig. 110, F, G).—The head of the Bird is small, and of a conical form. The anterior extremity is elongated, and terminated by a pointed or flattened beak, which allows the animal to cut the air with more facility.

Bones of the cranium.—The bones which compose the cranium are, as in Mammalia, an *occipital*, *parietal*, *frontal*, *ethmoid*, *sphenoid*, and two *temporals*. These bones are not isolated from each other, excepting during early life in the shell; and the ossifying process

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12, os quadratum; 13, malar bone. H, *Sternum:* 14, brisket or keel; 15, episternal process; 16, internal lateral process; 17, lateral external process; 18, membrane which closes the internal notch; 19, membrane of the external notch. I, etc., *Superior Ribs:* 20, posterior process of the fifth. J, *Inferior ribs.* K, *Scapula.* L, *Coracoid bone.* M, *Furculum:* *m*, *m*, its two branches. N, *Humerus.* O, *Ulna:* o, *radius.* P, P′, *Bones of carpus.* Q, Q′, *Bones of metacarpus.* R, First phalanx of the *large digit of the wing:* *r*, second phalanx of the same. R′, Phalanx of *thumb.* S, *Ilium.* S′, *Ischium.* S″, *Pubis:* 21, *sciatic foramen;* 22, *foramen ovale.* T, *Femur.* U, *Patella.* V, *Tibia.* X, *Fibula:* *y*, single bone of tarsus. Y, *Metatarsus:* 23, superior process representing a united metatarsal bone; 24, process supporting the claw. Z, etc., *Digits.*

which unites them is so rapid, that the cranium, shortly after hatching, is already a single piece. No detailed description of the separate bones will be given here, but only a few brief observations which may be of some utility.

Thus, the *occipital* bone shows for articulation with the spine only a single condyle, situated under the occipital foramen, and excavated by a slight groove. In Palmipedes, this bone is pierced, behind the crests which give attachment to the extensor muscles, by two foramina which penetrate the cranium, and represent permanent fontanella. The *parietal* bone is feebly developed, and formed from only two primary nuclei. The *frontal* is the largest bone of the cranium; its orbital process (Fig. 110, 1), incomplete, is supported by a particular piece (*posterior frontal*) fixed between the principal frontal bone, parietal, and posterior sphenoid, with which it is sometimes confounded. The *perpendicular lamina of the ethmoid* is considerable, and forms between the two orbits a thin vertical septum (Fig. 109, 8). Its posterior border is notched opposite to the optic foramen, and thus constitutes an opening which communicates between the two orbital cavities (Fig. 109, 9). It is also channeled, near its upper border, by a fissure which terminates by two openings at its extremities, one entering the cranium, the other the nasal cavities. This fissure and these foramina permit the passage of the ethmoidal nerve, which in this way traverses the orbit before arriving at its destination. The *ethmoidal cells* are more membranous than bony; their base is attached to a very delicate transverse plate, which is often membranous and not cribbled, and forms part of the anterior orbital wall. These cells replace, at the same time, the lateral masses of the ethmoid and turbinated bones of Mammalia. The *sphenoid* appears to be formed of a single piece, and shows on its sides two diarthrodial facets corresponding to the pterygoids. It is pierced by one foramen for the passage of the optic nerves; but this foramen opens on the outer and opposite side of the posterior notch of the interorbital septum, and thus allows each of the nerves passing through it to reach the eye for which it was intended.

It is worthy of remark, that an analogous disposition is also noticed in the Rabbit.[1] The *temporal* bones present at their base an articular surface corresponding to the square bone (*os quadratum*) (Fig. 109, 12, 12′). In the *Fowl* species, the zygomatic process forms a small flattened tongue, directed forwards, sometimes free, and at other times united by its superior border to the summit of the orbital process. These two eminences are exceedingly short in *Pigeons*. In *Palmipedes* they are consolidated and confounded so intimately, that it becomes impossible to distinguish them from one another. From this union results a long and strong process, which inclines forward and meets a particular prolongation of the os unguis, forming with it a real bony arch. This arch limits, below and outwardly, the orbital cavity.

Bones of the face.—The supermaxilla comprises: a *premaxilla*, two *nasal*, two *lachrymal*, two *palatine*, two *pterygoid*, two *zygomatic bones*, and a *vomer*. The inferior jaw has for its base a *maxillary bone*, which articulates with the cranium by means of two supplementary pieces named the *square bones*. The *premaxillary bone* (Fig. 110, 10) is formed, before hatching is completed, of two lateral pieces,

[1] This analogy is really striking, and might, in our opinion, serve as a basis for a new determination of the interorbital septum. We are tempted, indeed, to consider this bony lamina as the inferior sphenoid and the middle portion of the ethmoid in Birds. This manner of viewing it tends to confirm the ideas of M. Tabourin on the inferior sphenoid and the ethmoid of Mammals.

which represent the two small premaxillaries of Mammals. This bone is very considerable, and of itself forms the base of the upper beak, the form of which it determines; it is pointed and conical in the *Gallinacea*, and wide and flattened above and below in *Palmipedes*. In front it circumscribes the external openings of the nose, and is prolonged superiorly into two lengthy processes which dovetail between the nasal bones. Two inferior processes belonging also to this bone concur in the formation of the palatine roof. The *supermaxillaries*, analogues of the supermaxillaries of Mammals, are two rudimentary bones situated on the sides and at the base of the beak. They form a part of the palatine roof and the walls of the nasal cavities. The *nasal bones* circumscribe above, inwardly, and even outwardly, the external orifices of these cavities. The *palatine bones* encircle, as in Mammals, the guttural openings of the nose, and constitute in great part the roof of the palate; their posterior extremity lies against the pterygoids; the anterior joins the supermaxillaries and the inferior process of the premaxillary bone. The *pterygoids* extend obliquely from the sphenoid to the square bones, and are united to the sphenoid by diarthrodial articulation. The *zygomatic bones* have the form of two very thin stylets, and are united to the square bone by their posterior, and consolidated with the supermaxillary by their anterior, extremity. The *vomer* separates the guttural openings of the nose from one another.

The bones of the upper jaw are not fused to each other so rapidly as the bones of the cranium. The ascending processes of the premaxillary and nasal bones even remain for a long time united to the frontal bone by a simple synarthrodial articulation. This arrangement allows the upper beak to execute a certain elevating movement, of which we will speak when describing the articulations.

The *inferior maxillary bone* is originally formed of a great number of distinct segments, which are soon united into a solid piece. The *square*, *petrous*, or *bone of the tympanum* ought to be considered as detached from the temporal. It is prismatic in shape, and provided on its upper surface with a diarthrodial facet which unites it to the temporal, and on its lower face with another facet articulating with the branch of the maxilla. Outwards it joins the zygomatic bone, and inwards the pterygoid. Behind, it gives attachment to the membrane of the tympanum; and in front it presents a small eminence of insertion, which Meckel considered a second zygomatic process.

THORAX.—*Sternum* (Fig. 109, H 1).—The *sternum* of Birds, serving as a basis of support to the muscles moving the wings, should offer, and does in fact show, a remarkable degree of strength, because of the extraordinary volume of these muscles. And these being more powerful and energetic as the Bird exhibits a greater degree of aptitude for flight, it results that the structure of the sternum is solid in proportion as the creature is strong on the wing. For this reason, we may infallibly pronounce as to the extent and power of a bird's flight by an inspection of the sternum of individuals of its species. In this respect, however, we only announce what is well known to be a particular application of the rules established by the great law of concordance between the anatomical disposition of organs and their physiological finality.

Studied in *Palmipedes*, which will serve as a type for description, the sternum presents itself in the form of a large rectangular cuirass, elongated from before to behind, of itself constituting the inferior wall of the thoracic cavity, and also largely protecting the abdominal cavity. Its superior face is concave, while the inferior is convex, and entirely occupied by the insertion of the pectoral muscles.

It presents, on the median line, a thin and very salient ridge, named the *brisket* (*carina* or *keel*) (Figs. 109, 14; 111, B. 2), which in a remarkable manner multiplies the points of attachment of these muscles. The anterior border offers in its middle a small eminence of insertion, the *episternal* (Figs. 109, 15; 111, A 2). Laterally, two articular grooves are seen which correspond to the coracoids. The posterior border is cut by two notches which are often converted into foramina (Fig. 111, B 3, 3). On the lateral borders are observed small double articular facets answering to the inferior ribs. The angles which separate these two borders from the anterior are both prolonged into a little eminence, named by some authors the *costal process* (Fig. 111, A 33).

In the **Fowl,** the sternum is not so strong as in the **Goose** or **Duck.** On each side of the brisket it shows two wide notches, which greatly reduce its substance. These notches (Figs. 109, 18, 19; 111, A 6, 7), closed in the fresh state by membranes, are distinguished as external and internal. The latter, of greater size than the former, extends nearly to the extremity of the bone. From this division of the lateral plates of the sternum, result two long and slender processes directed backwards (Figs. 109, 16, 17; 111, A 4, 5). The external terminates by becoming widened, and forming a kind of bony plate, which covers the last inferior ribs.

The sternum of **Pigeons** is distinguished by the enormous development of the brisket. The two notches of the Fowl are also met with in these birds, but the internal is nearly always converted into a narrow foramen.

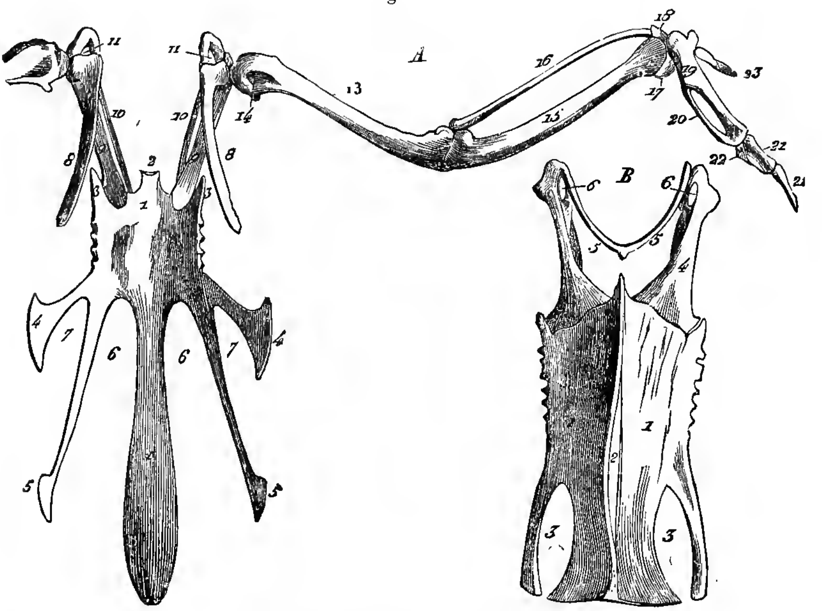
This comparative study of the sternum in the chief domesticated birds, leads us to appreciate the correctness of the principles just enunciated, with regard to the form and extent this bone may exhibit. The *Gallinaceous Birds*, properly so called, which fly little and badly, have the sternum singularly weakened by the deep notches cut in its lateral parts. With *Palmipedes*, the sternum is wide and but slightly notched, so that the Goose and Duck, which waddle along so awkwardly in our poultry yards, are capable of sustaining long and rapid flight, like that of the wild individuals of the same species. With regard to *Pigeons*, which are well known to be swift and powerful flyers, may this advantage not be due to the extraordinary development of the keel which constitutes the brisket?

Ribs (Fig. 109, *l*, etc.).—In the **Fowl** and **Pigeon** there are seven pairs of ribs; and in the **Duck** nine pairs. Articulated superiorly with the dorsal vertebræ, as in Mammals, these bones are provided, near their middle, with a flat eminence which commences at the posterior border, and is directed backwards and upwards, to rest by its free extremity on the external face of the next rib. These eminences (Fig. 109, 20) form an epiphysis at an early period, and are usually absent in the first and last ribs. They concur in an efficacious manner to increase the solidity of the thorax.

The costal cartilages of the Mammalia, are in Birds often transformed into veritable inferior ribs, joined to the superior ribs by a diarthrodial articulation (Fig. 109, J). These pieces are long and strong, and all terminate at their lower extremity by a double facet which articulates with the lateral border of the sternum; they are nearly always absent in the two first ribs. It is not rare to see the last united to the one before it, instead of passing directly to the sternum; in which case it comports itself like the asternal ribs of Mammals.

ANTERIOR LIMBS. *Shoulder-bone.*—The shoulder comprises: a *scapula*; a particular bone named the *coracoid* by Cuvier: and a *clavicle*, which forms, in coalescing with that of the opposite side, a single bone called the *fork* (*furculum*), or *os furculare*. The *scapula* (Figs. 109, K; 111, A 8) is narrow, elongated, and falciform, and shows no trace of a spine. Its anterior extremity only forms a portion of the glenoid cavity, and is united by means of a fibro-cartilage with the *fork* of the coracoid bone. The latter (Figs. 109, L; 111 A 9) is so named because it represents the coracoid process of Mammals, and is a long prismatic bone, directed obliquely from above downwards, and before to behind. Its superior extremity is often fused with the scapula, and united at an acute angle with that bone to form a portion of the articular cavity which receives the head of the humerus. Its inferior extremity is flattened from before to behind, and responds by a diarthrodial articulation to the anterior border of the sternum. The *coracoid* is long in Birds which fly slowly; it is, on the contrary, short, thick, and therefore very solid, in quick flyers. The *fork* (Figs. 109, M; 111,

Fig. 111.



STERNUM AND BONES OF THE WING.

A, *Sternum and wing-bones of the Fowl (upper face).* 1, Body of the sternum; 2, its episternal process; 3, 3, its costal processes; 4, 4, its lateral external processes; 5, 5, its lateral internal processes; 6, 6, internal notches; 7, 7, external notches; 8, scapula; 9, coracoid; 10, fork; 11, opening for the passage of the elevator of the wing; 13, humerus; 14, air-opening in that bone; 15, ulna; 16, radius; 17, ulna-carpal bone; 18, radio-carpal bone; 19, large metacarpal; 20, small metacarpal; 21, first phalanx of the large digit; 21′, second phalanx of ditto; 22, small phalanx lying beside the first bone of the large digit, and representing the remains of a third digit; 23, thumb.

B, *Sternum and shoulder-bone of a young Duck (inferior surface).* 1, 1, Sternum; 2, keel; 3, 3, lateral notches; 4, 4, coracoid; 5, 5, fork; 6, opening for the passage of the elevator of the wing.

B 5, 5) is a single bone, shaped like a V or U, situated at the base of the two wings, in front of the trunk, and in an oblique direction downwards and backwards. The two branches which form it represent the clavicles; they meet and are united at their inferior extremities, where they describe a curvilinear angle more or less open, attached to the brisket by means of a membranons ligament.

Their superior extremity rests within and opposite to the glenoid cavity, against the scapula and coracoid, forming with these bones a remarkable foramen, through which passes the tendon of the elevator muscle of the wing (Fig. 111, A 4, B 6). The forks play the part of an elastic spring, whose office it is to prevent the wings coming towards each other during contraction of the depressor muscles. The conformation of this bone is, therefore, like the sternum, related to the extent and power of flight; and for this reason it is that, in swift flyers, the two branches of the furculum are thick, solid, widely separated, and curved like a U; while in those which fly heavily and with difficulty, these branches are thin and weak, and joined at an acute angle. The latter formation greatly diminishes its strength, and lessens, in a singular manner, the reactionary power of the bony arch it represents.

Bone of the arm.—The humerus (Figs. 109, N; 111, A 13) offers an articular oval-shaped head, and an air-opening placed beneath this eminence. It is long in *Palmipedes*, ordinarily so in the *Gallinacæ proper*, and very short in *Pigeons*.

Bones of the forearm (Figs. 109, O, *o*; 111, A 15, 16).—The *radius* is much less voluminous than the ulna. The latter has an extremely short olecranon; and the two bones are separated from one another in their middle part to meet again at their extremities, where they are united by ligamentous bands in such a way as to render the movements of pronation and supination impossible. This mode of union, which nevertheless does not prevent the two bones from gliding slightly on each other in the direction of their length, has been wisely adopted by nature in order that the wing might strike the air, like an oar, by its inferior face; otherwise, the resistance of the aerial medium would make these two bones pivot, and cause the wing to present itself to the air in a wrong direction.

Bones of the carpus (Figs. 109, P, P′; 111, A 17, 17).—These are only two, and are distinguished by the names of *radius* and *ulna*, in consequence of their corresponding more particularly to these bones in other animals.

Bones of the metacarpus (Figs. 109, Q, Q′; 111, A, 19, 20).—These also number only two, and are separated at their middle portion, to be consolidated at their extremities.

Bones of the digital region.—The wing of a bird is composed of three digits. One of them, which resembles the thumb and forms the basis of the false wing, is composed of a single styloid-shaped phalanx, articulated at the base of a small particular process belonging to the superior extremity of the largest metacarpal bone (Figs. 109, R′; 111, A 23). The largest digit comprises two phalanges, which succeed the last bone (Figs. 109, R, *r*; 111, A 21, 21′). The third digit is represented by a small rudimentary phalanx (Fig. 109, A 22), which corresponds to the inferior extremity of the small metacarpal bone, and lies beside the first phalanx of the large digit in the closest manner.

It is well to remark that the hand and forearm are longer in proportion to the quality of flight; these two regions of the wing, for example, are very short in *Gallinaceous Birds*.

POSTERIOR LIMBS. *Coxa*, or *os iliac.*—This is a voluminous and very solid piece, particularly in walking birds, and composed, as in the Mammalia, of an *ilium*, *ischium*, and *pubis*. The *ilium* (Fig. 109, S), very long, is consolidated with the last two dorsal, the lumbar, and the sacral vertebræ; it is excavated on its internal face. The *ischium* partly incloses the side of the pelvic cavity; between its internal border and the external border of the ilium is an orifice which replaces the great ischiatic notch. Its inferior border is united to the *pubis*. The latter (Fig. 109, s″) is thin and elongated, and follows the direction of the inferior border of the ischium, with it circumscribing an *oval opening* more or less spacious (Fig. 109, 22). Its inferior extremity extends beyond the ischium, to curve inwards towards that of the opposite side, but without uniting with it. We do not, therefore, find the pelvic symphysis in Birds, and the pelvis is slightly open below, a circumstance which favours the passage of the egg through the cavity and out of the cloaca. The *cotyloid cavity* is perforated by an opening at the bottom, which passes through the bone.

Thigh-bone.—The *femur* (Fig. 109, T) is articulated inferiorly with the patella, tibia, and fibula. In all walking Birds, like the Gallinacæ, it is long and strong, as well as the bones below it.

Leg-bones.—The *patella* (Fig. 109, U) is wide and thin. The *tibia* (Fig. 109, V) terminates, below, by two condyles separated by a groove, which becomes articular behind. The *fibula* (Fig. 109, X) articulates by its head with the external condyle of the femur, and is cousolidated with the tibia ; it never descends to the inferior extremity of that bone.

Tarsal bones.—The tarsus appears to be altogether absent in Birds. Nevertheless, we may venture to consider, as a vestige of the bones of this region, a small bony nucleus buried in a fibro-cartilaginous mass which glides on the posterior pulley of the tibia. This nucleus (Fig. 109, Y) represents the calcaneum of Mammals.

Metatarsal bone.—A single metatarsal bone is found in Birds, articulating superiorly with the inferior extremity of the tibia, and terminating inferiorly by three pulleys which support the three principal digits. This bone (Fig. 109, Y) shows in the **Fowl**, near its inferior third, a conical process turned backwards, which serves as a base for the spur. Behind its superior extremity, it exhibits another which may be considered as a consolidated metatarsal bone (Fig. 109, 23).

Bones of the digital region (Fig. 109, Z, etc.).—All the domesticated Birds have four digits on the inferior members : three principal, directed forwards, and one rudimentary, carried backwards. The first, designated as internal, median, and external, articulate with the inferior pulleys of the metatarsal bones. The internal is formed by three phalanges, the second has four, and the third five. These phalanges are formed something like those of the Carnivora ; the last is pointed, conical, and enveloped in a horny sheath. The fourth digit, or thumb, is composed of three pieces ; one of these, the first, is generally considered as a rudimentary metatarsal bone. It is attached by fibro-cartilaginous tissue to the inner and posterior aspect of the inferior extremity of the principal metatarsal bone.

CHAPTER IV.

THEORY OF THE VERTEBRAL CONSTITUTION OF THE SKELETON.

IN the series of vertebrated animals, the bony pieces of the trunk bearing the name of vertebræ are those which offer the highest degree of fixity, and to which the existence or the arrangement of the others appears to be subordinate. This feature in organization, recognized by E. Geoffroy Saint-Hilaire and Professor Owen, has caused these authorities to assert that the type of construction of vertebrated animals is the vertebra.

After E. Geoffroy Saint-Hilaire and Professor Owen, several German, English, and French anatomists have studied the vertebral composition of the skeleton; and among the works published in France on this subject, must be specially noticed those of Lavocat. In principle, all the writers have arrived at the same conclusions, and only differ in some few details.

It is certain that the base of the vertebral column is formed by a series of bony segments. Each of these segments is called an *osteodesm*, and each osteodesm represents the *body* or *centrum* of a vertebra.

In examining the dorsal region, it is evident that to the body or centrum of a vertebra are added two complete osseous arches—a superior and an inferior. The superior arch is formed by the vertebral laminæ; the inferior by the ribs, their cartilages, and a portion of the sternum. The first is designated the *neural arch*, as it furnishes a protective case for the nervous centres; and the second, which more particularly protects the vascular system, is called the *hæmal arch* (see Figs. 112, 113).

The hæmal arch may have prolongations or *appendices* more or less developed, and comparable to the apophysary prolongations of the ribs in Birds and some Fishes.

Such is the general composition of a typical vertebra; but there are also to be distinguished in the neural and hæmal arches the following parts:—

NEURAL ARCH.

1. Neural parapophysis = the posterior costal cupola.
2. Neural metapophysis = the anterior costal cupola.
3. Neural diapophysis = the summit of the transverse process.
4. Neurapophysis = the vertebral lamina.
5. Neural spine = the summit of the spinous process.

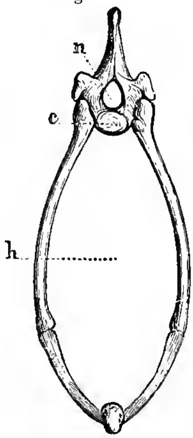
HÆMAL ARCH.

1. Hæmal parapophysis = the tuberosity of the rib.
2. Hæmal metapophysis = the head of the rib.
3. Hæmal diapophysis = the rib proper.
4. Hæmapophysis = the costal cartilage.
5. Hæmal spine = the corresponding sternal portion.

The vertebræ sometimes depart more or less from the model just described. They may vary not only from one species to another, but also in the same animal, and even in the same region. Thus, the neural arch may be absent, as has been observed in certain coccygeal vertebræ; or the hæmal arch is incomplete or null, as in the cervical or lumbar vertebræ; or, lastly, the arches are often unequal; though this inequality is of no importance, since their size is in relation to the volume of the parts they should protect.

Notwithstanding these differences and variations, or the transformations experienced by certain parts, there is not a bone in the skeleton which cannot be included in the vertebral type.

Fig. 112.



THORACIC OR PECTORAL VERTEBRA OF A MAMMAL.

c, Centrum; *n*, neural arch; *h*, hæmal arch.

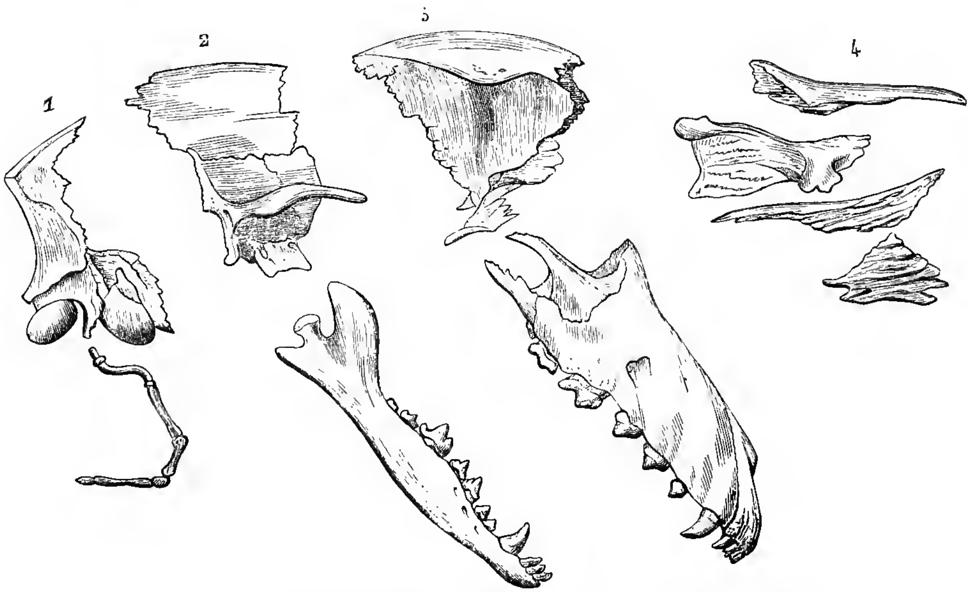
Fig. 113.

CAUDAL VERTEBRA OF THE TURBOT.

c, Centrum, *n*, neural arch; *h*, hæmal arch.

The vertebra being admitted as the type of construction of the skeleton, it is easy to find it in all the regions of the bony framework. In the thoraco-

Fig. 114.



CRANIAL VERTEBRÆ OF THE DOG. (AFTER LAVOCAT.)

1, Occipito-hyoideal vertebra; 2, parieto-maxillary vertebra; 3, fronto-mandibular vertebra; 4, naso-turbinal vertebra.

abdominal region, the centrum, neural arch, and hæmal arch are readily perceived; for in the lumbar vertebræ, the enormously developed transverse process indicates the existence of an intra-vertebral arch.

In the sacral region, the bony girdle of the pelvis represents the hæmal arch. The posterior limbs, articulating with the bones of the pelvis, also belong to the hæmal arch, and should be considered as appendices of this arch, analogous to the costal appendices of birds.

The cervical region may be compared to the sacral region; as in it the inferior hæmal arch is represented by the osseous ring supporting the anterior limbs—the scapulo-clavicular girdle. The limbs themselves are appendices of the cervical hæmal arch.

Difficulties begin to appear when the extremities of the trunk—the head and coccyx—come to be examined. Nevertheless, the composition of the coccyx is revealed when the caudal vertebræ of certain Fishes, especially those of the Pleuronectidæ, in which the neural and hæmal arches are complete, are examined (Fig. 113). But the vertebral constitution of the head remained for a long time an insoluble question, or it was solved in a contradictory manner by the naturalists who attempted it. Some admitted a single cranial vertebra; others included three or four; while others, again, found six or seven.

These difficulties and contradictory results may be understood, when it is borne in mind what profound modifications the vertebræ must have undergone to constitute the bones of the head.

At present the problem appears solved. The head is composed of four vertebræ, in which are found the various parts enumerated in the description of the typical vertebra.

In the four classes of vertebrata, the head is constantly formed of four vertebræ, which are determined as follows, according to Lavocat:—

Vertebræ.	Centrum.	Neural arch.	Hæmal arch.
Occipito-hyoideal.	Basilar process of the occipital.	Occipital (3 pieces). Mastoid walls of the tympanum.	Hyoideal apparatus (five pieces).
Parieto-maxillary.	Body of the posterior sphenoid.	Wing and pterygoid process of the posterior sphenoid. Squamous portion and zygomatic process of the temporal. Parietal.	Inferior maxilla (five pieces).
Fronto-mandibular.	Body of the anterior sphenoid.	Wing and pterygoid process of the anterior sphenoid. Posterior Frontal and its orbital process. Frontal.	Malar. Lachrymal. Palatine. Supermaxillary. Premaxillary.
Naso turbinal.	Vomer.	Ethmoid. Nasal.	Turbinated. Sub-ethmoidal.

The number of cranial vertebræ is invariable, as each is destined to lodge the organs of one of the four senses. The occipito-hyoideal receives the principal organs of hearing ; the parieto-maxillary osteodesm protects the sense of taste ; finally, the organs of vision are sustained by the fronto-mandibular vertebra, while the naso-turbinal contains the sense of smell.

Several anatomists, at the head of whom are Huxley and Gegenbauer, do not entirely share these views. They certainly admit the existence of the occipital vertebra, but it appears to them to be impossible to recognize the others. They remark that all the bones which constitute the spine are found in the primary cartilaginous skeleton ; so that, in order to establish the vertebral constitution of the head, it would be necessary to allot to the same cranial vertebra : 1. The pieces that are found in the cartilaginous cranium. 2. The other pieces which are developed in the fibrous tissue—those skeletal tegumentary pieces (temporals, parietals, etc.). It must also be observed that the division into vertebral bodies of the parts which form the base of the cranium, far from being easy in the lowest animals, is, on the contrary, only possible, with some trouble, in the highest classes. So that if the vertebral constitution of the head were a fact, it must be admitted that the differentiation of the bones at the base of the cranium is less advanced in Mammals than in the lower vertebrates.

The vertebral type is not, therefore, universally accepted by all anatomists.

SECOND SECTION.

The Articulations.

THE ARTICULATIONS IN GENERAL.

The different pieces constituting the solid framework of the animal body are, as has been said, united in such a manner that they can move one upon the other. From this union results the *articulations*, or *articular joints*, the construction of which will now be referred to in a general manner, before commencing a particular description of each.

Arthrology, or *Syndesmology*, is the name given to that division of anatomy which treats of the articulations. To form articulations, the bones correspond with each other by certain determined points of their periphery, which are named *articular surfaces*. Every articulation is, therefore, essentially constituted by two opposite osseous surfaces, simple or complex, which are moulded to each other. These are either contiguous, independent, and very movable—continuous with each other by means of a cartilaginous substance which confines them, if not to total immobility, at least to very limited movements ; or united by a fibro-cartilage, the elasticity of which permits a certain degree of displacement between the bones in contact.

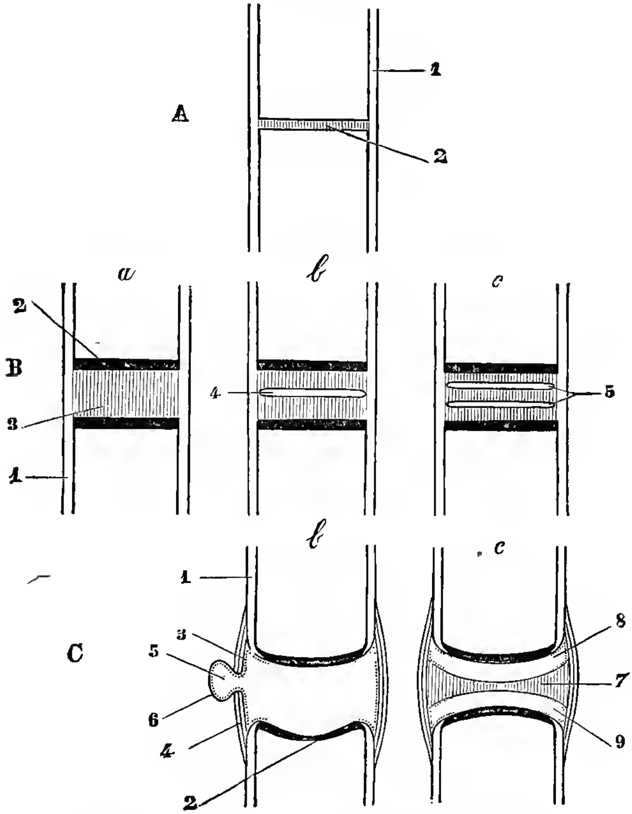
In the first case, the articulations are classed as *diarthroses*, or *movable articulations*.

In the second, they are designated *synarthroses*, *sutures*, or *immovable articulations*.

In the third, they are *amphiarthroses*, or *mixed articulations;* so termed because they participate in the movements of the other two classes : synarthroses, by the continuity established between the articular surfaces ; and diarthroses, by the extensive motion they permit.

The general characters that distinguish each of these three great classes of articulations will be successively studied.

Fig. 115.



PLANS OF THE DIFFERENT CLASSES OF ARTICULATIONS.

A, Suture: 1, periosteum; 2, sutural ligament. B, Amphiarthrosis: *a*, first degree—1, periosteum; 2, articular cartilage; 3, interarticular ligament: *b*, second degree—4, single cavity in the interarticular ligament: *c*, third degree—5, double cavity in the interarticular ligament. C, Diarthrosis: *b*, simple diarthrosis—1, periosteum; 2, articular cartilage; 3, epithelial layer of the synovial membrane (dotted line); 4, fibrous capsule; 5, cul-de-sac of the synovial membrane; 6, fibrous layer of the synovial membrane: *c*, double diarthrosis—7, interarticular meniscus; 8, 9, cavities of the two synovial membranes.

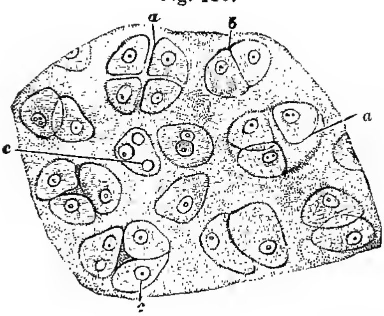
General Characters of Diarthroses.

We ought to consider, in the diarthrodial articulations (Fig. 115, C, *b* and *c*) : 1. The contiguous *bony surfaces* which form them. 2. The cartilaginous layers (*cartilages of incrustation*) which cover these. 3. The fibrous or fibro-cartilaginous tissue (*articular fibro-cartilages*) which complete them, when they are not shaped so as to be reciprocally adapted to each other. 4. The *ligaments* which maintain them in contact. 5. The *serous membranes* (*synovial capsules*) that cover the internal face of the latter, and which secrete the *synovia*, a kind of animal oil that facilitates the gliding of the articular surfaces. 6. The *movements* of which these articulations may be the seat. 7. Their *methodical classification.* 8. Their *nomenclature.*

Articular Surfaces.—These surfaces have the common character of being destitute of asperities, so that they can glide with the greatest facility on each other. They are designated, according to their form, by the names of *facets*, *heads*, *condyles*, *cotyles*, *glenes*, *pulleys*, etc. There is no need to revert to their general description, as they have already been sufficiently studied in the osteology; so we will confine ourselves to repeating that they are found at the extremities of long bones, on the faces of short bones, and on the angles of wide bones. We may mention, also, that they are often excavated by one or several depressions named *synovial fossæ*, or hollows for the insertion of ligaments. The first are a sort of natural reservoirs which receive the unctuous fluid secreted by the interarticular serous membranes; the second give attachment to interosseous ligaments.

Cartilages of Incrustation.—This designation is given to the layers of cartilaginous matter which, as it were, varnish the articular surfaces they adhere to by their inner face; their free surface is distinguished by a remarkable polish and brilliancy. Thicker towards the centre than at the circumference when they cover bony eminences, these cartilages show an inverse disposition when they line cavities. They are elastic, of a pearly whiteness, and resisting—though they are soft enough to be cut by a sharp instrument; in a word, they possess all the physical characteristics of the primary cartilage of bones. They appear to be formed of parallel fibres placed perpendicular to the bony surfaces, and implanted in these by one of their extremities; the opposite extremity corresponding to the free surface of the cartilage. Viewed by the microscope, they are found to present the characters of true or hyaline cartilage.

Fig. 116.



SECTION OF BRANCHIAL CARTILAGE OF TADPOLE.

a, Group of four cells separating from each other; *b*, pair of cells in apposition; *c*, *c*, nuclei of cartilage-cells; *d*, cavity containing three cells. These cells are embedded in the finely granular matrix, or fundamental substance.

The fundamental matter is amorphous and homogeneous; but under the influence of slight dessication, there appears in the hyaline substance a partitioning formation, which may be regarded as an agent in the distribution of the nutritive juices in the substance of the cartilaginous tissue (Renaut).

The cavities (cartilage capsules) are irregular, and more or less wide. They contain from one to five cells without walls, and their contents—slightly granular—have in the centre of each cell one or two nuclei with nucleoli (Fig. 116). These cavities are elongated, and are directed almost perpendicularly towards the osseous articular surface in the deep layer; in the middle layer they are round; and they are lenticular, and parallel to the surface of friction, in the superficial layer.

(It has been stated that a membrane lines these spaces. In addition to the granular matter observed in the cells, it is not rare to find fat globules. The nuclei of the cells vary from $\frac{1}{4000}$ to $\frac{1}{2400}$ of an inch in diameter. The cells multiply endogenously.)

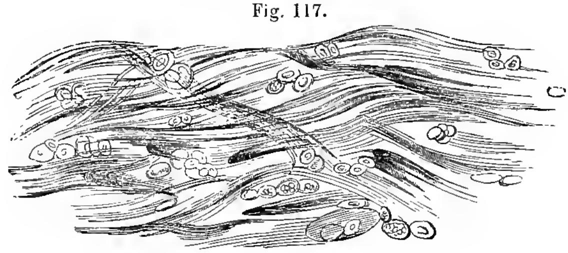
The cartilage cells are insoluble in boiling water ; consequently, so far as their chemical composition is concerned, they are distinct from the fundamental substance.

The diarthrodial cartilages have no vessels or nerves.

The presence of cartilages of incrustation in the articulations is of the greatest importance. When they are worn, absorbed, or transformed into bone in consequence of certain articular maladies, the movements become painful and very difficult. With regard to the part they play in the economy, it may be said that : 1. They favour, by their smoothness, the gliding and displacement of the bones. 2. They attenuate, by their suppleness and elasticity, the violent shocks to which the articulations are exposed. 3. They resist the wear and deformation of the articular surfaces.

Complementary Fibro-cartilages.—There are two kinds of complementary fibro-cartilages. Some (*interosseous*) represent circular cushions which pad the margins of certain cavities, filling up the notches that might render these imperfect. They increase the depth of these cavities, and protect their borders from injury—for example, the coxo-femoral articulation. Others (*inter-articular*) are interposed between articular surfaces when these do not exactly fit each other—as when two opposing extremities are convex. It may be remembered that the lateral tuberosities of each tibial surface present, for articulation with the condyles of the femur, two convex diarthrodial faces, the coaptation of which is rendered perfect by the interposition between each condyle and corresponding tibial surface, of a crescent-shaped fibro-cartilage, which for this reason has been named a *meniscus*. In other joints, these interarticular fibro-cartilages are shaped like discs or biconcave lenses. There then result double diarthroses (Fig. 115, c, e) : example, the temporo-maxillary articulation. (Fibro-cartilage also covers bony surfaces over which the tendons play, as on the trochlear surface of the humerus, postero-inferior face of the navicular bone, and elsewhere. In these situations it is named *stratiform fibro-cartilage.*) These organs are formed sometimes by fibrous, at other times by cartilaginous tissue ; their mode of association need not be referred to here, though it may be observed that the cartilage is more particularly found in all those points where there is most articular friction. They receive very few vessels, and it is questionable if they have nerves.

Fig. 117.



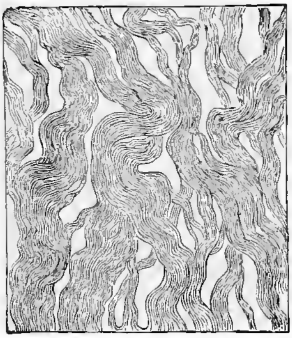
FIBRO-CARTILAGE, MAGNIFIED 155 TIMES.
Showing interlacement of fibrous fasciculi, with scattered groups of cartilage-cells.

Ligaments.—These are bands which unite contiguous diarthrodial surfaces. They are sometimes formed of white fibrous tissue, and sometimes of yellow ; hence their division into two great classes of *white* and *yellow ligaments*.

a. The *white ligaments* are distinguished by the pearly whiteness of their tissue and want of elasticity. Those which are found around the margin of articulations are termed *peripheral*, and those in their interior are designated *interosseous* or *interarticular ligaments*.

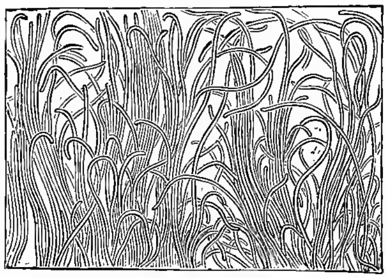
The *peripheral ligaments* are generally composed of parallel fibres collected in fasciculi, or spread out as membranes. In the first they are called *funicular*, or *ribbon-shaped*; in the second, they are termed *membraniform*, or *capsular*. The *funicular ligaments* are short, round, or flattened bands, attached by their extremities to the two bones they unite; they are lined on their inner aspect by the synovial capsule, and are covered externally by tendons, aponeuroses, muscles, vessels, or nerves. The *capsular ligaments* are often complete—that is

Fig. 118.



WHITE OR NON-ELASTIC FIBROUS TISSUE.

Fig. 119.



YELLOW OR ELASTIC FIBROUS TISSUE, FROM THE LIGAMENTUM NUCHÆ.

to say, they envelop the whole articulation like a sack. At other times they are incomplete, and then they are simple membranes, binding together the different funicular ligaments of a joint.

The *interosseous ligaments*—less numerous than the preceding—are often formed of interlacing fibres; they are always *funicular*, and fixed by their extremities into excavations in the centre of articular surfaces.

b. The *yellow ligaments* are all *peripheral*, *funicular*, or *membranous*, and enjoy a marked degree of elasticity, which permits them mechanically to bring back to their usual position the bony levers that have been momentarily displaced. These ligaments, which are powerful auxiliaries to the muscular forces, give permanent equilibrium to the weight in certain parts of the body, which incessantly tend to fall to the ground; for instance, the cervical ligament of Solipeds and large Ruminants. The ligaments are always assisted in their action by atmospheric pressure, which is exerted over all the surface of the body; and also frequently by the tendons and aponeurosis of muscles, and even by the muscles themselves, when they pass over an articulation or are inserted in its vicinity. In several regions the ligaments are more or less confounded with tendons or aponeuroses—as in the anterior extensor tendon of the phalanges and superior sesamoid ligament, the ligaments of the femoro-tibial articulation, and the aponeuroses of the posterior portion of the superficial gluteal muscle.

Synovial Capsules.—These are very thin membranes of a serous character, intended to secrete the *synovia*. They are composed of two layers: a deep, formed by fasciculi of connective tissue; the other, superficial, formed by an endothelium. The first sometimes adheres intimately to the inner face of the funicular or membranous ligaments of the articulation; at other times it is loosely attached to them by an abundance of connective tissue. The second layer is constituted by a single row of flattened polygonal cells, except at the bottom of certain grooves, where they are more or less crowded. Though belonging to the serous membranes, the synovial membranes do not form complete sacs, as, after lining the internal surface of the ligaments, they cease at the articular margins.

Direct observation demonstrates that the cartilages have no covering, and that there is no synovial membrane on their surface. The anatomists who imagined that the thin pellicle, which can be rendered evident in cutting the surface of cartilage obliquely and separating it by teazing, was a membrane, were deceived, as this pellicle has not the texture of a serous membrane; and it is not vascular, for it has never been possible to inject vessels on the surface of such cartilages, nor yet in their substance. Neither is it covered with epithelium, and, if submitted to microscopical examination, it has all the characters of cartilage.

Pathological facts prove nothing in favour of the existence of a synovial membrane on cartilages.

It may be accepted, then, that the synovial membrane never extends to the surface of articular cartilage; but, after being fixed around the margin of a diarthrodial surface, it is reflected in every direction to line the internal surface of the ligaments, and become attached to the periphery of the diarthrodial surface in contact with the other, so that it entirely isolates the interior of the joint from the peri-articular connective tissue.

There are generally found within articulations, little masses of fat which push the synovial membrane enveloping them inwards. Erroneously considered by Clopton Havers as glands for the secretion of synovia, these accumulations of fat have been named *synovial fringes*, or *villi*. They are more particularly numerous in the neighbourhood of the articular margins—that is, on the border of diarthrodial surfaces. They are formed by a prolongation of the synovial membrane, which covers some connective tissue fibres associated with adipose cells, or an amorphous substance provided with nuclei.

The synovial membrane, after lining the inner surface of ligaments, sometimes escapes between these, forming a hernia. The term *synovial culs-de-sac* has been given to these external prolongations of the articular serous membrane. This membrane often covers the inner surface of a tendon or ligament, in order to facilitate their gliding over a bony eminence.

The *synovia* is a viscid, colourless, or slightly yellow fluid, in its physical characters somewhat resembling oil; it does not possess them, however, so far as its composition is concerned, for chemical analysis has not demonstrated the presence of fatty principles. It is the albumen it contains which gives to it its viscidity, and which fits it for lubricating the articular surfaces over which it is spread. Its use in the animal economy is absolutely identical with that of the greasy substances employed to lubricate the axles of carriages.

To the means of union described under the names of ligaments and synovial membranes, may be added atmospheric pressure, the influence of which is relatively considerable, as the experiments of Weber have demonstrated.

Movements.—The movements peculiar to diarthrodial articulations are divided into seven principal classes:

1. *Simple gliding*, the only movement possible between two plane or undulating facets.

2. *Flexion*, which brings two bony pieces nearer each other, by closing more or less their angle of union.
3. *Extension*, the inverse movement, during which the bones are straightened on each other.
4. *Adduction*, which brings the inferior extremity of the movable bone towards the median line.
5. *Abduction*, the contrary movement to the preceding.
6. *Circumduction*, or the sling movement, during which the bone passes successively through the last four positions.
7. *Rotation*, in which one bone pivots on another.

Classification of the Diarthroses.—The basis of this classification is founded on the configuration of the articular surfaces and the nature of the movements they permit. This double base serves to establish five kinds of diathrodial articulation :

1. *Enarthrosis*, characterized by the reception of an articular head within a cavity of appropriate form. This articulation, the surfaces of which are derived from a sphere, may be the seat of the most extensive and varied movements—flexion, extension, abduction, adduction, circumduction, and rotation. Example : the coxo-femoral articulation.

2. The *trochlean*, *angular ginglymoid*, or *perfect hinge articulation*, when the articular surfaces are formed into trochlea, reciprocally fitting into each other, and the movements of which—flexion and extension only—are executed, from before to behind, with the precision of a hinge. Example : the tibio-tarsal articulation.

3. The *pivot*, *trochoid*, or *lateral ginglymoid articulation*, is a diarthrosis formed by a pivot which turns in a semi-cylindrical cavity. Rotation is the only movement. Example : the atlo-axoid articulation.

4. The *condyloid*, or *imperfect hinge articulation*, which permits, like the preceding, the two principal movements of extension and flexion, and the accessory movements of rotation or lateral inclination. The articular surfaces, though very diversely shaped, nevertheless exhibit in all the articulations one or more condyles opposed to an equal number of oval excavations. Example : the femoro-tibial articulation.

5. *Arthrodia*, or *planiform diarthrosis*, is constituted by plane or nearly plane facets. Gliding is the only possible movement. Example : the carpo-metacarpal articulation.

Nomenclature.—The names of the articulations are usually those of the bones which form them. For instance, the *scapulo-humeral* articulation is the joint between the scapula and humerus ; the *intervertebral* articulations join to each other the various bones constituting the spine. When the qualifying name of an articulation is composed of two elements, as in the first instance, it is well to place first the word which indicates the bone usually most fixed.

General Characters of the Synarthroses.

Sutures (Fig. 115, A) are the temporary articulations which exist only at an early period of life. They nearly all disappear in the adult animal, in consequence of the bones forming them becoming consolidated. They belong almost exclusively to the boues of the head.

Articular Surfaces.—The bones forming these come in contact by their borders or angles, which, for this purpose, generally present very uneven surfaces.

Sometimes they are cut perpendicularly and simply roughened ; at other times they are bevelled, and joined by means of fine laminæ or trifling inequalities ; again, they are notched into deep and sinuous dentations ; and lastly, one bone is fixed into a groove cut in the other. It will be understood that such formations of the articular surfaces will limit their movements, and assure the solidity of their union.

Modes of Union.—A fibrous tissue interposed between these synarthrodial surfaces, unites them closely to each other. It has absolutely the same texture as the primary cartilage of the bones, and, like it, possesses the property of becoming ossified after having been vascularized. This ossification, which causes the disapppearance of the sutures, occurs earlier inwards than outwards. The periosteum, in passing from one bone to another, also concurs in bringing about a more complete synarthrosis. It should, therefore, be included in their means of union.

Movements.—These are very obscure, and only noticeable in young animals, by the elasticity they communicate to the bony walls of the cranium or face. In the adult, they may be said to be null.

Classification.—There are four principal descriptions of *sutures :*

1. When two wide bones correspond by means of denticulations fitting into each other, the suture is named *true*, *limbosa*, *serrated*, or *dentated*. Example : the articulations uniting the three portions of the parietal bone. 2. If the opposite borders of two bones in contact are widely bevelled, one inwards, the other outwards, it forms a *scaly* or *squamous suture* (*squamosa*). Example : the parieto-temporal articulations. 3. When the union of bones takes place by plane or roughened surfaces, cut perpendicularly on their borders or angles ; this constitutes the *harmonia suture*, or *suture by juxtaposition* (or *apposition*). Example : the occipito-temporal articulations. 4. The *schindylesis*, *mortised suture*, *synchrondrosis*, or *gomphosis*, results from the reception of a bony plate into a groove more or less deep in another bone. Examples : the spheno-frontal and supermaxillo-nasal articulations ; the teeth in the alveolar cavities.

General Characters of the Amphiarthroses or Symphyses.

Articular Surfaces.—They are frequently smooth, and formed almost on the same model as the diarthrodial surfaces. They are covered by a thin layer of cartilage ; but, instead of being smooth and polished, they are more or less rugged, without, however, presenting the anfractuous disposition of the majority of synarthrodial surfaces.

Modes of Union.—The organs which perform this office are : 1. Fibro-cartilage, which establishes continuity between the articular surfaces. 2. Ribbon-shaped and peripheral ligaments (Fig. 115, B *a*). These latter do not differ from the analogous bands attaching the diarthrodial articulations. With regard to the fibro-cartilage, it is distinguished from the complementary discs of these same articulations, by a less intimate mixture of the cartilaginous and fibrous elements entering into its composition. The last may be sometimes absent, as well as the peripheral bands ; and then the articulation only differs from the synarthroses by the extent of motion it permits. Occasionally, the interarticular fibro-cartilages are excavated by one or two little narrow cavities (Fig. 115, B *b*, *c*) ; but these are never lined by a synovial membrane, like the diarthrodial cavities.

MOVEMENTS.—The amphiarthroses only permit of a see-saw or swinging movement, the extent of which depends on the thickness of the intermediate fibro-cartilage.

CLASSIFICATION.—Only one kind of amphiarthrosis is recognized in the Horse, the most remarkable of which is found in the articulations between the bodies of the vertebræ.

CHAPTER II.

ARTICULATIONS OF MAMMALIA IN PARTICULAR.

IN the special study of the articulations, the same order will be followed as for the bones; the articulations of the spine will be first noticed, then those of the head, thorax, and anterior and posterior limbs.

Preparation.—The preparation of the bones which have been described, has not been made the subject of any particular recommendation, because it suffices, in order to study them, to remove the soft parts by which they are surrounded, either by boiling, maceration, or scraping. But when we come to examine the soft textures, in order to do so profitably it is necessary to learn beforehand the rules which should be followed in their preparation. The following directions are given with regard to the study of the articulations:—

1. To prepare the articulations, young subjects are chosen in preference to those advanced in years, because the density of the connective tissue in them is not so great, and this tissue is easily removed from around the ligaments. As these are prepared with difficulty when the external surface is in a dry state, care should be taken, before dissecting them, to have them excluded from the air by covering them with damp cloths, or with the skin of the animal.

2. It is convenient to separate the articulation we wish to dissect, by sawing through the bones at a certain distance from the articular surfaces. The manipulation of the part is then rendered easier, and its dissection can be made under the most favourable conditions.

3. It is necessary to preserve, as carefully as possible, the muscles surrounding the articulations, in order to be able to study their relations with the ligaments which bind these. If it be absolutely requisite to remove them, their insertions corresponding to the articulation should always be retained.

4. The capsular ligaments should be first studied, as they have soon to be removed, the better to show the funicular ligaments. These, in their turn, must be sacrificed in order to display, by different sections, the interosseous ligaments, when they are present. Lastly, the two articular surfaces should be completely separated, so as to examine their conformation.

5. The synovial membranes, with their different *culs-de-sac*, being a very important study—with reference to the diagnosis and treatment of articular tumours—it is convenient to devote a special piece to the examination of these serous membranes. It is very useful to inject their interior with plaster or tallow coloured black, in order to distend their cavities, and thus aid the study of their relations with ligaments, tendons, or muscles.

6. When an articulation is completely dissected, it may be left exposed to the air for some time. When the ligaments begin to dry, they are more visible and easier studied.

For the preparation of each articulation it is not necessary to give any directions; a glance at the figures accompanying the description will suffice to dispel any embarrassment the student may experience, while he always requires particular indications.

ARTICLE I.—ARTICULATIONS OF THE SPINE.

These articulations comprise all those of the vertebræ with each other.

Preparation.—In order to properly study the vertebral joints, the spine of one subject should be freed from all the muscles surrounding it; this being done, portions consisting of at least two vertebræ from the cervical, dorsal, and lumbar regions, should be detached from it. In the portions from the cervical regions, the interlamellar ligaments and the capsules of the articular processes are easily dissected; and on the dorsal region portions, the interspinous, supra-spinous, interlamellar, and common inferior ligaments, can be examined. On those portions from the lumbar region, in a horizontal section through the spinal canal, the inferior face of the interlamellar ligaments and the common superior vertebral ligament will be seen; while in those from the dorsal region, a good idea will be derived of the common inferior vertebral ligament. The intervertebral ligaments can be studied in vertical and horizontal sections of the bodies of the vertebræ from any region.

A second subject, which should be fixed in the *third position* (*see* Preparation of the Muscles), is necessary for the dissection of the supra-spinous, dorso-lumbar, and cervical ligament. This may be effected by removing the muscles which occupy the vertical channels above the cervical vertebræ (*see* Preparation of the Cervical Regions).

Intervertebral Articulations.

The vertebræ articulate: 1. By their bodies. 2. By their spinal or annular portion. There results from this union two kinds of articulation, which must be studied separately, as they do not belong to the same class. It is well to mention, however, that the general details into which this study leads us, apply only to the articulations uniting the last six cervical vertebræ, all the dorsal and lumbar vertebræ, and the first sacral vertebra.

Union of the Vertebræ by their Bodies.—The articulations forming this union are so many amphiarthroses.

Articular surfaces.—The vertebral bodies come into contact by the surfaces which terminate them before and behind. In the cervical region these surfaces represent, anteriorly, a real head; posteriorly, a cotyloid cavity which receives the head of the next vertebra. Beginning from the first dorsal vertebra and passing on to the sacrum, these surfaces tend to become effaced and more and more plane, though they still preserve their convexity and concavity.

Means of union.—1. By fibro-cartilages interposed between the articular surfaces. 2. By a common superior vertebral ligament. 3. By a common inferior vertebral ligament.

a. Intervertebral fibro-cartilages (Fig. 121, 1, 1).—These are circular or elliptical discs, convex in front, concave behind, and solidly fixed by their faces to the articular planes which they separate. The fibro-cartilaginous substance composing them consists of concentric layers, which become denser and closer to each other as they near the circumference; they even disappear towards the centre of the disc, where this substance becomes pulpy, and assumes the histological characters of pure cartilage. It may be remarked, that each of these layers is made up of a collection of thick parallel filaments, which cross with those of other layers like an X, and are attached by their extremities to the articular surfaces. From this arrangement results so intimate an adherence between the vertebral bodies and their intermediate fibro-cartilages, that an attempt to disunite them is more likely to cause a fracture of the former. The fibro-cartilages, thicker in the cervical and lumber regions than in the dorsal, respond by their circumference to the two common ligaments. Those which separate the vertebræ of the back concur to form the intervertebral cavities, intended for the reception of the heads of the ribs, and give attachment to the interosseous costo-vertebral ligaments.

b. Common superior vertebral ligament (Fig. 126, 1).—This ligament extends from the axis to the sacrum, and is lodged in the spinal canal. It is a long fibrous band cut on its borders into wide festoons. By its inferior face, it is attached to the intervertebral discs, and the triangular imprints on the upper faces of the bodies of the vertebræ. Its superior face is in contact with the dura mater, through the medium of an abundant cellulo-adipose tissue. Its borders are margined by the intra-vertebral venous sinuses (*venæ basium vertebrarium*).

c. Common inferior vertebral ligament (Fig. 127, 5).—Situated under the spine, this ligament is absent in the cervical, and the anterior third of the dorsal region. It only really begins about the sixth or eighth vertebra of the latter region, and is prolonged in the form of a cord—at first narrow, then gradually widening until it reaches the sacrum, on the inferior surface of which it terminates by a decreasing expansion. From its commencement, it is attached to the inferior crests of the bodies of the vertebræ and the intervertebral discs. By its inferior face, it is in contact with the posterior aorta.

(Leyh commences this ligament at the seventh cervical vertebra, and says that it adheres to the crests on the bodies of the dorsal and lumbar vertebræ, as well as to the lower face of the sacrum and coccyx. At the fifth dorsal vertebra it widens and thickens, and in the lumbar region is bound up with the pillars of the diaphragm, and confounded on each side with the large ligaments of the pelvis.)

UNION OF THE VERTEBRÆ BY THEIR SPINAL PORTIONS.—Each vertebra, in uniting by its annular portion with that which follows or precedes it, forms a double arthrodial joint.

Articular surfaces.—These are the facets cut on the anterior or posterior articular processes, and which have been described when speaking of the vertebræ themselves. They are covered by a thin layer of cartilage.

Means of union.—1. A common supra-spinous ligament. 2. Interspinous ligaments. 3. Interlamellar ligaments. 4. Ligamentous capsules, proper to the articular processes.

a. Capsules proper to the articular processes (Fig. 124, 5).—Each anterior articular process is maintained against the corresponding posterior process, by a direct band. This is a peripheric capsule attached around the diarthrodial facets, lined by a synovial membrane which facilitates their gliding, and covered, outwardly, by the insertions of some spinal muscles. These capsules, yellow and elastic in the cervical region, are composed of white fibrous tissue in the dorso-lumbar region. Very developed at the neck, in consequence of the thickness of the articular tubercles they envelop, they become reduced, near the middle of the back, to some fibres which cover, outwardly, the diarthrodial facets in contact.

b. Common supra-spinous ligament.—This ligament, the name of which sufficiently indicates its situation, extends from the sacrum to the occipital bone, and is divided into two portions—one posterior, or *supra-spinous dorso-lumbar ligament*; the other anterior, or *supra-spinous cervical ligament.* These two ligaments, although continuous with one another, yet differ so strikingly in form and structure that they are best described separately.

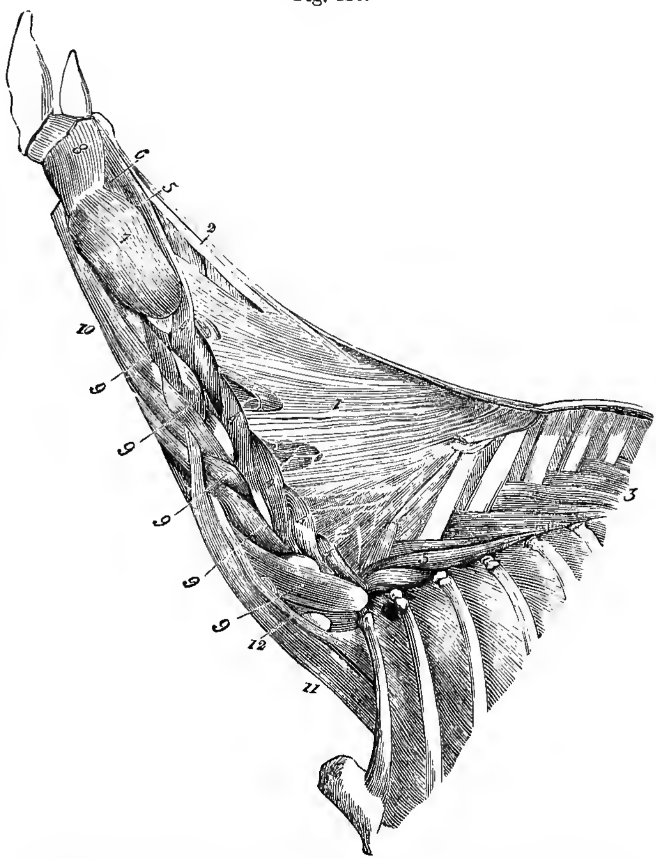
1. *Supra-dorso-lumbar ligament* (Fig. 127, 2).—This is a cord of white fibrous tissue, which commences behind on the sacral spine, and ceases in front, about the inferior third of the dorsal region, by insensibly assuming the texture and elasticity of the cervical ligament, with which it is continuous. It is attached in its course to the summits of all the lumbar spinous processes, and to the ten or twelve last dorsal. On the sacral spine, it is confounded with the superior ilio-sacral ligaments. In the lumbar region, it is united on each side to the aponeuroses of the longissimus dorsi muscles.

2. *Supra-spinous cervical*, or simply *cervical ligament* (*ligamentum nuchæ, liga-*

mentum colli) (Fig. 120, 1, 2).—This ligament is entirely formed of yellow fibrous tissue, and constitutes, in the median plane of the body, a very remarkable elastic apparatus, which separates the superior cervical muscles of the right side from those of the left, and plays the part not entirely of an articular band, but rather of a permanent stay, charged to balance the weight of the head.

In the cervical ligament there is distinguished a *funicular* and a *lamellar portion*. The first, usually called the *cord* (*funicular* or *cordiform* portion) of the ligament, is a wide funiculus which extends directly from the first dorsal spinous

Fig. 120.

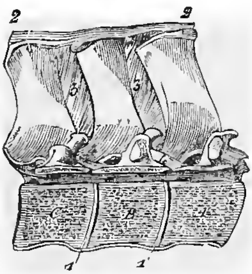


CERVICAL LIGAMENT AND DEEP MUSCLES OF THE HORSE'S NECK.

1, Lamellar portion of the cervical ligament; 2, funicular portion of the same.

processes to the summit of the head. Divided into two lateral lips by a median groove, this cord is continued posteriorly by the dorso-lumbar ligament, and is inserted, anteriorly, into the tuberosity of the occipital bone. It is covered above by a mass of fibro-adipose tissue, which, in certain common-bred horses, is very abundant. Below, it gives rise, in its posterior two-thirds, to the majority of the fibres belonging to the lamellar portion. On the sides, it receives the insertions of several cervical muscles. The *lamellar portion*—comprised between the funicular portion, the spinous processes of the second dorsal vertebra, and the cervical vertebræ, constitutes a vast triangular and vertical septum, which itself results from the apposition of the two laminæ that lie back to back, and are united by connective tissue ; they are bordered above by the two lateral lips of the cord. The elastic fibres which enter into their composition are given off either from the latter, or from the spinous processes of the second and third dorsal vertebræ; they are directed downwards or forwards, and reach the spinous processes of the last six cervical vertebræ, into which they are inserted by so many digitations, becoming confounded with the interspinous ligaments of the neck. The fibres of the two last digitations are few in number, widely separated from one another, and united by many anastomosing branches, which make them appear as a kind of wide network. The laminæ of the cervical ligament are in relation, outwardly, with the superior branch of the ilio-spinal ligament, the intertransversalis colli muscles, and the complexus muscle.

Fig. 121.



INTERVERTEBRAL ARTICULATIONS.

A, B, C, Bodies of three dorsal vertebræ divided longitudinally and vertically to show (1, 1) a section of the intervertebral discs; 2, supraspinous dorso-lumbar ligament; 3, interspinous ligament; 4, fibrous fascia, constituting the proper capsule of the articular processes in the dorsal region.

(This important structure, which is, in reality, the mechanical stay and support of the heavy head and neck of quadrupeds, and is usually termed the *ligamentum nuchæ*, is all but absent in Man, being represented in him by a thin narrow band—or rather two thin planes of fibres, the *ligamenta subflava*. It is described by Leyh as if there were not two portions, and that excellent anatomist does not appear to insist sufficiently on the difference between the dorso-nuchal and the dorso-lumbar divisions. Percivall, who almost entirely neglects the ligaments, also makes no distinction. The difference in structure, elasticity, and situation, warrants the distinction made by Chauveau. As already indicated, the function of this ligament—and more particularly of its nuchal division—is to maintain the head and neck in their natural position during repose, and to allow the most extensive movements at other times.)

c. Interspinous ligaments (Fig. 121, 3).—Fibrous laminæ fill the interspinous spaces, and are attached, before and behind, to the opposite borders of the spinous processes, which they unite. They are confounded superiorly with the supra-spinous ligament, and are continued inferiorly by the interlamellar ligaments—forming two lateral planes which are applied against each other, like the laminæ of the cervical ligament, and covered outwardly by the intertransversalis colli muscles.

In the region of the neck, the interspinous ligaments are yellow and elastic. In the dorso-lumbar region, they are formed by fasciculi of white fibrous tissue, loosely united to each other at their extremities, and directed very obliquely backwards and downwards. In consequence of this disposition, and notwithstanding their inextensibility, they permit the separation of the spinous processes. Their lateral surfaces are divided by a layer of grey elastic fibres, which cross like an X the direction of the preceding fasciculi. Very abundant in the anterior moiety of the dorsal region, these fibres operate, by their proper elasticity, in bringing the spinous processes towards each other.

d. Interlamellar, or interannular ligaments.—Situated, as their name indicates, between the vertebral laminæ, and divided into two lateral moieties, these ligaments appear to be produced by the two fibrous planes of the preceding ligaments, which, on arriving at the base of the spinous processes, separate from one another to be carried outwards. Their anterior border is inserted into the posterior margin of the vertebral lamina in front. Their posterior border is fixed to the anterior border and inferior face of the lamina behind. Their superior face is in relation with some spinal muscles, and their inferior face is in contact with the dura mater. Outwardly, they are confounded with the capsules proper to the articular processes. Yellow and elastic in the cervical region, these ligaments are white and inelastic in the dorso-lumbar region.

CHARACTERS PROPER TO SOME INTERVERTEBRAL ARTICULATIONS. 1. *Intercoccygeal ana sacro-coccygeal articulations.*—These articulations are adapted to the rudimentary type of the vertebræ they unite. The coccygeal bones only come in contact by their bodies—their spinal laminæ being reduced to the merest traces, or are altogether absent. The anterior and posterior articular surfaces of each vertebra are convex, and the interarticular fibro-cartilages, hollow on both faces, resemble a biconcave lens. With regard to the peripheral bands, they are represented by a bundle of longitudinal fibres spread over the surface of the bones, which they envelop in a common sheath.

2. *Intersacral articulations.*—The sacral vertebræ being fused into one piece —the os sacrum—there is no occasion to study the true articulations in this region. It may be remarked, however, that the supra-spinous dorso-lumbar ligament is continued on the sacral spine, and that there exist between the processes formed by this spine, true interspinous ligaments.

3. *Sacro-lumbar articulation.*—In this articulation, the great thickness of the fibro-cartilage is to be remarked ; and, in addition, that the last lumbar vertebra corresponds with the sacrum not only by its body and articular processes, but also by the oval and slightly concave facets shown on the posterior border of its transverse processes, which are adapted to analogous slightly convex facets on the sides of the base of the sacrum. The bundles of fibres thrown from one bone to another from around these *sacro-transversals* (real planiform diarthroses) maintain the articular surfaces in contact, and cover, outwardly, the synovial membrane which facilitates their gliding.

4. *Articulation of the two last lumbar vertebræ.*—This is distinguished by the presence, between the transverse processes, of a planiform diarthrosis, like that of the sacro-transversal just noticed. These two articulations are only found in Solipeds.

5. *Atlo-axoid articulation.*—This is so far removed by its conformation and special uses from the other intervertebral articulations, that it will be described as an extrinsic articulation of the head and spine. (See Articulations of the Head.)

THE MOVEMENTS OF THE SPINE IN GENERAL.—Each intervertebral articulation is the seat of very obscure movements, the separate study of which offers little interest. But these movements, when conjoined with those of the other articulations, result in bending the whole spine in a somewhat marked manner, and producing either the *flexion*, *extension*, or *lateral inclination* of this flexuous column.

When *flexion* takes place, the spine is arched upwards, the common inferior ligament is relaxed, the spinous processes separate from one another, and the supra-spinous ligament, becoming very tense, soon imposes limits to this movement.

Extension is effected by an inverse mechanism, and is checked by the tension of the common inferior ligament and the meeting of the spinous processes.

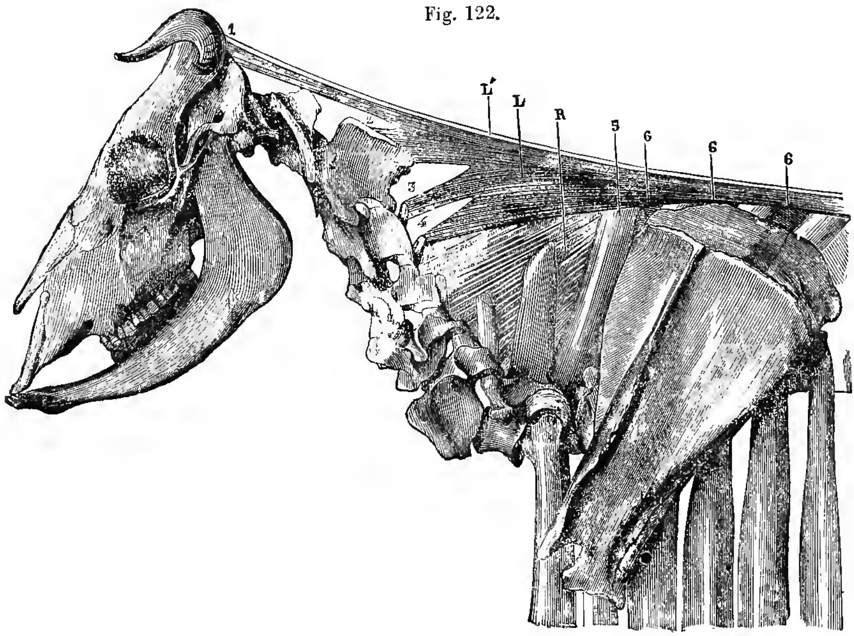
Lateral inclination takes place when the spine bends to one side. This movement is very easily executed in the cervical and coccygeal regions, but is arrested by the ribs and the costiform processes in the dorso-lumbar region.

A *circumflex movement* is possible at the two extremities of the vertebral column—neck and tail; for they pass easily from extension to lateral inclination, and from this to flexion, etc.

Owing to the elasticity of the intervertebral fibro-cartilages, the spine is endowed with a very limited amount of *rotation*, or rather of *torsion*.

For the special study of the movements of each spinal region, reference must be made to what has been already said (p. 43) regarding the mobility of this part.

Fig. 122.



CERVICAL LIGAMENT OF THE OX.

L, L', The two laminæ which form the cord of the cervical ligament: 1, 2, 3, 4, the four anterior digitations of the cordiform portion. R, Its accessory portion: 5, first dorsal vertebræ; 6, 6, 6, interspinous ligament of the dorsal region.

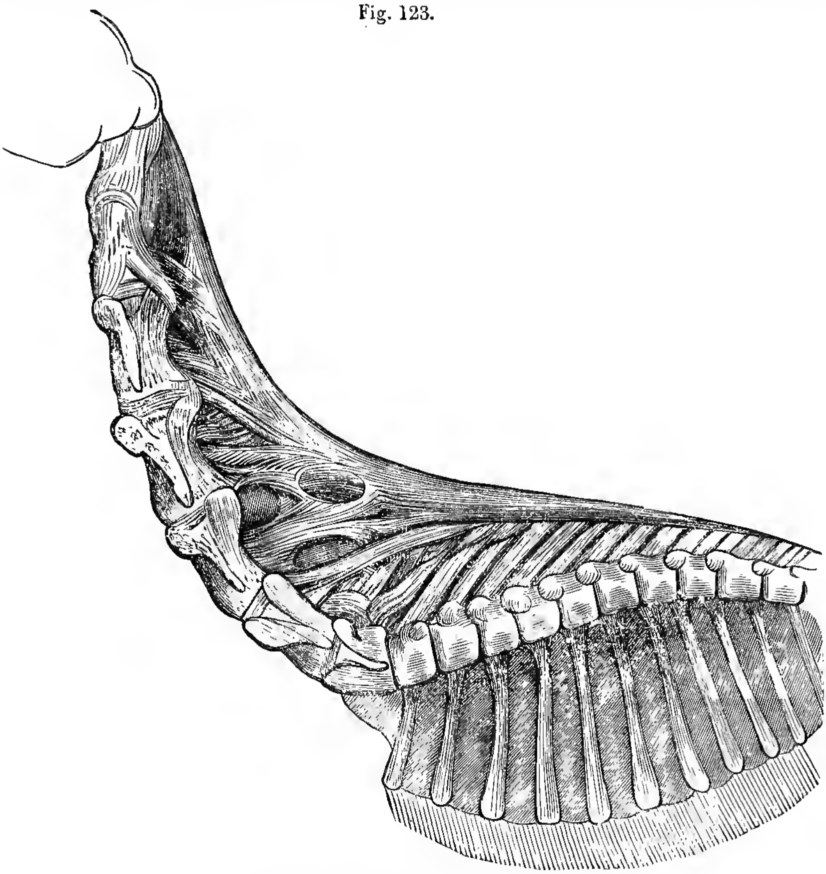
Differential Characters in the Vertebral Articulations and Ligaments in the other Animals.

A. In the **Ox** the intervertebral discs are much thicker than in the Horse. The *common inferior vertebral ligament* is very strong in the lumbar region. The *supra-spinous dorso-lumbar ligament* is composed of yellow elastic tissue. The *cervical ligament* is much more developed than in Solipeds, in consequence of the greater weight of the head; and it presents a conformation altogether special, which M. Lecoq has made known in the following terms: "On leaving the withers, the *supra-spinous ligament* ceases to cover the head of the spinous processes, and extends from each side in a wide and strong band, taking points of attachment on the sides of the processes, and becoming separated, on leaving that of the first dorsal vertebra, into two parts—a superior and inferior. The first reaches the cervical tuberosity in the form of a thick cord united to the cord of the opposite; the other thins off into a band, which is attached to the posterior half of the spinous process of the axis, and to that of the third and fourth vertebræ. A production of the same kind—an auxiliary to the principal portion—leaves the anterior border of the spinous process of the first dorsal vertebra, and is attached to that of the fourth, fifth, sixth, and seventh vertebræ. The superior border of this auxiliary ligamentous production, is concealed between the two lamina of the principal ligament."[1]

B. Camel.—In this animal, the *common supra-spinous ligament* is entirely composed of yellow elastic tissue; it is therefore impossible to distinguish, physically, a dorso-lumbar and a cervical portion. It is remarkable for its thickness and width; and its dimensions increase from behiud to before, especially from the second lumbar vertebra. At the fifth, sixth, seventh, eighth, ninth, and tenth dorsal vertebræ an elastic band is given off from its borders; as this descends, it gradually becomes thinner until it reaches the external intercostal muscles.

From the ninth dorsal vertebra, the *supra-spinous ligament* divides into two layers, which are placed against the lateral faces of the spinous processes. In the cervical region, the layers

Fig. 123.



CERVICAL LIGAMENT OF A YOUNG CAMEL.

become rounded, are joined to each other by means of connective tissue, and describing an S-shaped curve, become inserted into the occipital bone.

They give off, from their inferior border, six digitations, which are attached to the spinous processes of the last six cervical vertebræ. An accessory leaf is situated between the two portions just described; it is detached from the anterior border of the spinous process of the first dorsal vertebra, and is fixed anteriorly into the two last cervical vertebræ.

C. Pig.—The *Pig*, remarkable for the shortness of its neck and the limited movements of this region, does not show any *cervical ligament*, properly so called. It is replaced by a superficial fibrous raphé, extending from the occipital bone to the spinous process of the first dorsal vertebra.

[1] *Journal de Médecine Vétérinaire*, p. 122. Lyons, 1848.

D. Carnivora.—The *Cat* has no *cervical ligament*, and shows, instead, a raphe like the Pig. In the *Dog*, the ligament is reduced to a simple cord, continued from the dorso-lumbar ligament, and goes no further than behind the spinous process of the axis. In the *Cat*, the *interspinous ligaments* are replaced by small muscular fasciculi; in the *Dog*, this substitution only takes place in the cervical region. The laminæ of the first coccygeal vertebræ possess the principal characters which distinguish perfect vertebræ, and are united by vestiges of the articular bands which exist in the other regions of the spine.

Article II.—Articulations of the Head.

We will first study the two extrinsic articulations which are the centre of the movements of the head on the spine—the *atlo-axoid* and *occipito-atloid articulations*. Afterwards, we will pass to the examination of the joints which unite the different bones of the head.

1. Atlo-axoid Articulation (Fig. 124).

Preparation.—It suffices to remove the soft parts from around the articulation, to expose the interannular, the interspinous, and the inferior odontoid ligament. To examine the superior odontoid ligament and the synovial membrane, one half the atlas and axis must be separated by sawing longitudinally through them from one side to the other.

This may be considered as the type of the trochoid articulation.

Articular surfaces.—To form this articulation, the axis offers its odontoid pivot and the undulated diarthrodial façets at its base. The atlas opposes to the pivot the concave semi-cylindrical surface hollowed on the superior face of its body; and for the lateral undulated facets it has analogous facets cut on the transverse processes, on each side of the vertebral canal.

Mode of union.—1. An odontoid, or odonto-atloid ligament. 2. An inferior atlo-axoid ligament. 3. A superior ditto. 4. A fibrous capsule.

a. Odontoid ligament (Fig. 124, 3).—Continuous with the common superior vertebral ligament, very short and strong, flattened above and below, and triangular in shape, the odontoid ligament is composed of glistening white fibres, fixed behind in the superior channel of the odontoid process, and inserted in front on the transverse ridge which separates the superior face from the inferior arch of the atlas, as well as on the imprints situated in front of this ridge. It is covered, on its lower face, by the synovial membrane of the articulation; and its upper surface is in contact with the spinal dura mater. It sends some bands within the condyles of the occipital bone.

b. Inferior atlo-axoid ligament.—This is a wide, thin, and nacrous-looking band, extending from the inferior face of the axis to the inferior tubercle of the atlas, and is covered by the longus colli muscle; it is united to the synovial membrane by its deep face, and confounded on its borders with the fibrous capsule to be immediately described. It represents the common inferior vertebral ligament.

c. Superior atlo-axoid ligament.—This exactly represents the interspinous ligaments of the other cervical articulations. Yellow, elastic, and formed like the two lateral bands, it is continuous, laterally, with the capsular ligament. It represents the interspinous and interlamellar ligaments.

d. Capsular ligament.—This, it may be said, is only the interlamellar ligament proper to the atlo-axoid articulation. It commences from the sides of the preceding ligament, and becomes united to the inferior atlo-axoid, after contracting adhesions with the borders of the odontoid ligament. In this way it encloses the articulation and the spinal canal. Before and behind, it is attached to the anterior or posterior margin of the bones it unites. Its external face is in contact with the great oblique muscle of the head; its internal responds, in its inferior half, to the articular synovial membrane, and its superior moiety to the spinal dura mater. It is analogous to the capsules in other regions. (Leyh describes this ligament as the interannular).

Synovial membrane.—This lines the odontoid ligament and atlo-axoid ligaments, and the articular portion of the peripheral capsule.

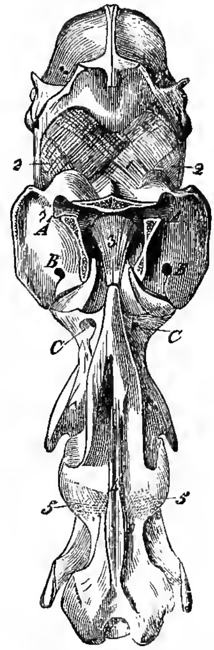
Movements.—*Rotation*, the only movement possible in the atlo-axoid articulation, is effected in the following manner: the axis remains fixed, and the first vertebra, drawn to one side chiefly by the great oblique muscle, rotates on the odontoid pivot, carrying the head with it.

The rotation movements of the head have, therefore, this diarthrosis for a centre, and not the atloido-occipital articulation.

In the **Dog** and **Cat,** the odontoid ligament is replaced by three particular ligaments: 1. Two *lateral cords*, rising in common from the summit of the odontoid process, and inserted, each on its own side, within the condyles of the occipital bone. 2 A *transverse ligament*, passing over the odontoid process, which it maintains in its place against the inferior arch of the atlas, and is attached by its extremities to the superior face of the latter. A small synovial capsule facilitates the gliding of the odontoid process beneath this ligament. The articular synovial membrane always communicates with that of the occipito-atloid articulation.

In the **Pig,** the disposition is nearly the same as in the Carnivora.

Fig. 124.



ATLO-OXOID AND OCCIPITO-ATLOID ARTICULATIONS (the upper arch of the atlas has been removed to show the odontoid ligament).

1, 1, Middle accessory fasciculi; 2, 2, lateral fasciculi of the capsular ligament of the occipito-atloid articulation; 3, odontoid ligament; 4, interspinous ligament uniting the second and third vertebræ of the neck; 5, fibrous capsule uniting the articular processes of these vertebræ. A, Anterior internal foramen of the atlas converted into a groove by the section of the bone; B, B, vertebral foramina of the atlas; C, C, foramina replacing the anterior notches of the axis.

2. Occipito-atloid Articulation (Fig. 124).

(*Preparation.*—Dissect away all the soft parts that pass from the neck to the head and cover the articulation, and more particularly the flexor, the recti, and the small oblique muscles of the head. To expose the synovial membranes, open the sides of the capsular ligament.)

This is a condyloid articulation.

Articular surfaces.—In the atlas, the two cavities which replace the anterior articular processes and the heads of the other vertebræ; in the occipital bone, the two condyles flanking the sides of the occipital foramen.

Mode of union.—A single capsular ligament envelops the entire articulation; it is attached by its anterior border to the margin of the occipital condyles, and by its posterior to the anterior contour of the atlas. Thin and slightly elastic in its inferior half, this ligament presents, superiorly, four reinforcing fasciculi: two middle, which intercross in X—whence the name "cruciform," sometimes given to this ligament (Fig. 124, 1, 1); and two lateral, which pass from the sides of the atlas to the base of the styloid processes (Fig. 124, 2, 2). It is lined by the synovial membranes, and is enveloped externally by a large number of muscles, which protect the articulation and greatly strengthen it everywhere. Among these may be particularly noticed the recti muscles of the head, the small oblique, and the complexus. There is also the cord of the cervical ligament.

Synovial membranes.—These membranes are two in number—one for each condyle and corresponding atloid cavity. Sustained above, below, and outwardly by the capsular ligament, they are related inwardly to the dura mater and the fibrous tractus which, from the odontoid ligament, is carried to the internal face of the occipital condyles.

Movements.—*Extension*, *flexion*, *lateral inclination*, and *circumduction*, are the possible movements of the occipito-atloid articulation.

In the **Pig, Dog,** and **Cat,** this articulation—strengthened, as it is, by the capsular and odontoido-occipital ligaments already mentioned—has only one synovial capsule.

3. Articulation of the Bones of the Head with each other.

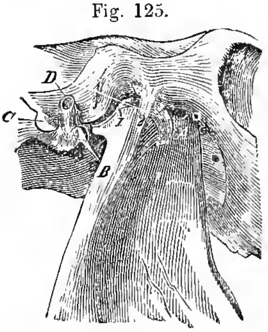
If we except the articulation which unites the inferior jaw to the cranium—the temporo-maxillary—and the hyoideal articulations, it will be found that all the bones of the cranium and face are united to each other by synarthrosis, forming the different kinds of sutures already generally described (p. 170). Nothing is to be gained by entering into more detail with regard to these articulations, as it will be found sufficient to call to mind the topographical description of each bone entering into their formation.

4. Temporo-maxillary Articulation (Fig. 125).

(*Preparation.*—Remove the masseter muscle and the parotid gland. Saw through the head about the middle line. Open the articulation externally, to exhibit the interarticular meniscus.)

The lower jaw, in its union with the cranium, constitutes a double condyloid articulation.

Fig. 125.



TEMPORO-MAXILLARY ARTICULATION.

1, Interarticular fibro-cartilage; 2, external fasciculus of the capsular ligament. A, Base of the coronoid process; B, neck of the maxillary condyle; C, mastoid process; D, external auditory hiatus.

Articular surfaces.—With the temporal bone, these are the condyle, the glenoid cavity, and the supra-condyloid process at the base of the zygomatic process. The glenoid cavity is not lined by cartilage, and appears to be merely covered by synovial membrane. On the maxillary bone is the oblong condyle situated in front of the coronoid process.

Interarticular fibro-cartilage.—The articular surfaces just named are far from fitting each other accurately; this is only accomplished by the interposition of a fibro-cartilaginous disc between the temporal and maxillary bones. This disc is a kind of irregular plate, flattened above and below, thicker before than behind, and moulded on each of the diarthrodial surfaces it separates. Its superior face, therefore, presents: in front, a cavity to receive the condyle of the temporal bone; behind, a boss which is lodged in the glenoid cavity. The inferior face is hollowed by an oblong fossa, in which the maxillary condyle is lodged (Fig. 125, 1).

Mode of union.—A fibrous envelope—a true *capsular ligament*—surrounds the articulation, and is attached by its borders to the margin of the articular surfaces it unites. Formed, outwardly, by a thick fasciculus of white vertical fibres (Fig.

125, 2), this ligament becomes greyish-coloured and elastic for the remainder of its extent, and greatly diminishes in thickness, especially in front. Its inner face is covered by the synovial capsules, and adheres to the circumference of the interarticular fibro-cartilage. Its external face is related, in front, to the temporal and masseter muscles; behind, to the parotid gland; inwardly, to the external pterygoid muscle; and outwardly, to a fibrous expansion which separates it from the skin. (Leyh mentions a lateral external and a posterior ligament for this articulation, but Chauveau and Rigot evidently look upon these as portions of the capsular.)

Synovial membranes.—This articulation has two synovial sacs—one above the other—which are separated by the fibro-cartilaginous disc.

Movements.—The temporo-maxillary articulation is the centre of all the movements performed by the lower jaw. These are: *depression*, *elevation*, *lateral motion*, and *horizontal gliding*.

The lower jaw is *depressed* when it separates from the superior one, and is *elevated* when it approaches this. These two opposite movements are executed by a mechanism of such great simplicity, that it need not be described here. *Lateral movements* take place when the inferior extremity of the jaw is carried alternately to the right and left. It then happens that one of the maxillary condyles, taking with it the fibro-cartilage, is brought into contact with the temporal condyle, while the other is embedded in the glenoid cavity of the opposite side. The *horizontal gliding* is effected from behind to before, or *vice versâ*. In the first case, the two maxillary condyles are carried at the same time under the temporal condyles, bearing with them the fibro-cartilages. In the second case, they are drawn into the glenoid cavities, and rest against the supra-condyloid eminence, which prevents their going further. It will be understood, after this brief description, that the presence of the fibro-cartilages singularly favours the lateral movements and horizontal gliding of the lower jaw.

In the **Pig**, the temporo-maxillary articulation is formed after the same type as that of Rodents, and allows very extensive movements from before to behind—a circumstance due to the complete absence of the supra-condyloid eminence.

In the **Dog** and **Cat**, the maxillary condyle is exactly fitted to the temporal cavity. This disposition, in giving great precision to the movements of depression and elevation, restrains in a singular manner the lateral and horizontal gliding motions. The interarticular fibro-cartilage is extremely thin in these animals.

In the **Rabbit**, the narrow condyle of the maxilla moves from before to behind and to each side, on the temporal bone, the articular surface of which is very elongated and destitute of a subglenoid eminence.

5. Hyoideal Articulations.

(*Preparation.*—Disarticulate the lower jaw, and dissect away from the right of each articulation the muscles that may conceal the view.)

These are of two kinds—*extrinsic* and *intrinsic*. The first comprise the two *temporo-hyoideal* articulations; to the second belong the joints which unite the different pieces of the hyoid bone—the *interhyoideal articulations*.

Temporo-hyoideal Articulations.—These are two amphiarthrodial joints, in the formation of which each great cornu of the hyoid bone opposes its upper extremity to the hyoideal prolongation lodged in the vaginal sheath of the temporal bone. An elastic cartilage, from $\frac{4}{10}$ to $\frac{6}{10}$ of an inch in length, unites the two bones in a solid manner; and it is owing to the flexibility of this cartilage that the hyoid bone can move entirely on the temporal bones.

INTER-HYOIDEAL ARTICULATIONS.—*A.* The great cornu articulates with the small one, by an amphiarthrosis analogous to the preceding. To form this articulation, these two pieces of bone are joined at an acute angle, through the medium of a more or less thick cartilaginous band, in the centre of which there is often a little bony nucleus—the styloid nucleus, or kerato-hyal bone. This cartilage is elastic and flexible, and permits the opening and closing of the articular angle at the summit of which it is placed.

B. Each styloid cornu is united to the body of the hyoid bone, or basihyal, by an arthrodial articulation. The articular surfaces are: for the hyoideal branch, the small cavity terminating its inferior extremity; for the body, the convex lateral facet situated at the origin of the thyroid cornua. These surfaces are covered by cartilage, and enveloped by a small synovial sac and a peripheral fibrous capsule. They can glide on each other in nearly every direction. (Median and superior hyoideal capsular ligaments are described by Leyh as sometimes present. The latter unites the upper and middle branches, and the former the middle with the inferior branches. They are absent when these branches are confounded with the superior ones.)

ARTICLE III.—ARTICULATIONS OF THE THORAX.

These are also divided into *extrinsic* and *intrinsic*. The first—named costo-vertebral—unite the ribs to the spine. The second join the different bones of the thorax together; they comprise: 1. The chondro-sternal articulations. 2. Chondro-costal articulations. 3. The articulations of the costal cartilages with each other. 4. The sternal articulation perculiar to the larger Ruminants and the Pig. All these joints will be first studied in a special manner, then examined in a general way as to their movements.

Extrinsic Articulations.

ARTICULATIONS OF THE RIBS WITH THE VERTEBRAL COLUMN, OR COSTO-VERTEBRAL ARTICULATIONS.

(*Preparation.*—This is simple. No difficulty need be experienced except in exposing the interarticular ligament, and this is effected by sawing through one of the dorsal vertebra transversely, close to the posterior intervertebral joint formed by that bone. A few cuts of the bone forceps will then show the whole extent of the ligament.)

Each rib articulates with the vertebral column by two points—its head and its tuberosity. The first is received into one of the intervertebral cavities hollowed out on the sides of the spine, and is therefore in contact with two dorsal vertebræ; the second rests against the transverse process of the posterior vertebra. From this arrangement arises two particular articulations belonging to the arthrodial class, which are named *costo-vertebral* and *costo-transverse.*

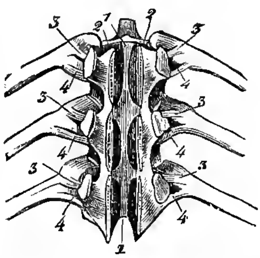
COSTO-VERTEBRAL ARTICULATIONS.—*Articular surfaces.*—Pertaining to the rib, we have the two convex facets of the head, separated from each other by a groove of insertion, and covered by a thin layer of cartilage. On the vertebræ, the concave facets which, by their union, form the intervertebral cavity; these facets are also covered with cartilage, and separated, at the bottom of the cavity, by the corresponding intervertebral disc.

Mode of union.—1. An *interarticular ligament* (Figs. 126, 2; 127, 1), fixed in the groove in the head of the rib, and attached to the superior border of the intervertebral disc, which it encircles upwards and inwards, to unite on the median line with the ligament of the opposite side. 2. An *inferior peripheral ligament* (Fig. 127, 2, 3, 4), flat above and below, thin and radiating (whence it is often named the *stellate* ligament), formed of three fasciculi, which are fixed in common on the inferior face of the head of the rib, and in diverging are carried over the bodies of the two vertebræ and the intervertebral disc. Lined above by the synovial membranes, this ligament is covered below by the pleura. (Leyh includes a capsular ligament for the head of the rib, and another for the costal tuberosity. He probably considered the synovial membrane of these articulations as such.)

Synovial membranes.—These are two in number—an anterior and posterior, lying against each other, and separated in part by the interarticular ligament they cover. Supported below by the stellate ligament, above they are directly in contact with the levatores costarum muscles, and with vessels and nerves.

COSTO-TRANSVERSE ARTICULATIONS. *Articular surfaces.*—In the rib, the

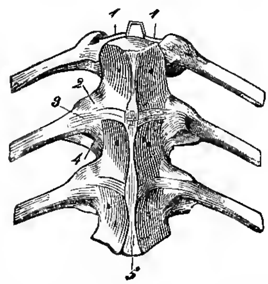
Fig. 126.



ARTICULATIONS OF THE RIBS WITH THE VERTEBRÆ, AND OF THESE WITH EACH OTHER (UPPER PLANE).

1, Spinal canal, upper face, showing the common superior ligament; 2, interarticular costo-vertebral ligament; 3, interosseous costo-transverse ligament; 4, posterior costo-transverse ligament.

Fig. 127.



ARTICULATIONS OF THE RIBS WITH THE VERTEBRÆ, AND OF THESE WITH EACH OTHER (INFERIOR PLANE).

1, Interarticular costo-vertebral ligament; 2, 3, 4, fasciculi of the stellate, or inferior costo-vertebral ligament; 5, common inferior vertebral ligament.

diarthrodial facet cut on the tuberosity. In the vertebra, the analogous facet on the outside of the transverse process.

Mode of union. Two ligaments bind this articulation: 1. The *posterior costo-transverse ligament* (Fig. 126, 4), a white fibrous band attached by its extremities behind the transverse process and the costal tuberosity, lined by synovial membrane, and covered by the transverse insertions of several spinal muscles. 2. The *anterior costo-transverse*, or *interosseous ligament* (Fig. 126, 3), a fasciculus of short, thick, white fibres, fixed on the anterior surface of the transverse process near its base, and in the rugged excavation on the neck of the rib. This ligament is invested, posteriorly, by the synovial membrane, and covered in front by pads of adipose tissue which separate it from the costo-vertebral articulation.

Synovial membrane.—This is a small particular capsule, kept apart from the posterior synovial membrane of the costo-vertebral articulation by the costo-transverse interosseous ligament.

CHARACTERS PECULIAR TO SOME COSTO-VERTEBRAL ARTICULATIONS.—1. The first, and sometimes the second, costo-vertebral articulation has no interosseous ligament, and only exhibits one synovial membrane. The intervertebral cavity which concurs in forming the first is often excavated between the last cervical and first dorsal vertebræ.

2. The two or three last costo-transverse articulations are confounded with the corresponding costo-vertebral joints. They have no proper serous membrane, but the posterior synovial membrane of the latter is prolonged around their articular surfaces.

Intrinsic Articulations.

A. The Chondro-sternal or Costo-sternal Articulations.

(*Preparation.*—To show the articulation of the ribs with the cartilages, these with the sternum, and the cartilages with each other, carefully remove the pleura, the triangularis sterni muscle, the diaphragm, the transverse muscle of the abdomen, then the pectorals, the great oblique, the transversalis of the ribs, and the intercostal muscles.)

The first eight ribs, in resting upon the sternum by the inferior extremity of their cartilages, form eight similar arthrodial articulations.

Articular surfaces.—Each sternal cartilage opposes to one of the lateral cavities of the sternum, the convex and oblong facet at its lower extremity.

Mode of union.—The diarthrosis resulting from the union of these two surfaces is enveloped everywhere by bundles of white, radiating, fibrous tissue, which constitute a veritable ligamentous capsule. The superior part of this capsule—known as the *stellate* or *superior costo-sternal ligament*, is covered by the triangularis sterni muscle; it is joined to a fibrous cord lying on the superior face of the sternum, and which is confounded in front with that of the opposite side. The inferior portion—the *inferior stellate* or *costo-sternal ligament*—is in relation with the pectoral muscles.

Synovial capsule.—There is one for each articulation.

Characters proper to the first costo-sternal articulation.—The first costo-sternal articulation is not separated from its fellow of the opposite side; so that these two joints are, in reality, only one, and the two cartilages lying close to each other correspond by a small diarthrodial facet, continuous with that for the sternum. The two sternal facets are inclined upwards, and confounded with one another. Only one synovial cavity exists for this complex articulation, which unites the two first ribs to each other and to the sternum.

B. Chrondo-costal Articulations uniting the Ribs to their Cartilages.

These are synarthrodial articulations, the movements of which are very obscure. They are formed by the implantation of the cartilages in the rugged cavities the ribs present at their inferior extremities. The solidity of these articulations is assured by the adherence of the fibro-cartilages to the proper substance of the ribs, and by the periosteum which, in passing from the bone to the cartilage, plays the part of a powerful peripheral band.

In the **Ox**, the sternal ribs, in uniting with their cartilages, form a true ginglymoid diarthrosis, the movement of which is facilitated by a small synovial capsule.

C. Articulations of the Costal Cartilages with each other.

The ribs, attached to each other by means of the intercostal muscles, are not united by real articulations; neither are their cartilages of prolongation. But the asternal cartilages are bound together by a small yellow elastic ligament, which is carried from the free extremity of each to the posterior border of the preceding cartilage; the anterior border of the first asternal cartilage is directly united to the posterior border of the last sternal cartilage, through the medium of the perichondrium and very short ligamentous bands. This same asternal cartilage is also bound to the inferior face of the xiphoid appendage by a small white ligament (the *chondro-xiphoid*), under which passes the anterior abdominal artery.

D. Sternal Articulation peculiar to the Ox and Pig.

It has been already shown that in these animals the anterior piece of the sternum is not consolidated with the second portion. The two are united by a diarthrodial articulation; and for this purpose the anterior presents a concave surface, the posterior a convex one. Bundles of peripheral fibres firmly bind them to each other, and a special small synovial capsule facilitates their movements, which are very limited.

The Articulations of the Thorax considered in a General Manner, with Regard to Movements.

The thorax can increase or diminish in diameter, in an antero-posterior and a transverse direction; whence arise the dilatation and contraction of this cavity—the *inspiratory movements* accompanying the entrance of the external air into the lungs, and the *expiratory movements* expelling the air contained in these organs.

The variations in the antero-posterior diameter of the chest being due to changes in the figure of the diaphragm, need not be noticed here. But the transverse variations being the result of the play of the costal arches on the spine and sternum, it is advantageous to study the mechanism which presides in the execution of their movements.

The costal arches, being inclined backwards on the middle plane, the space they enclose in their concavity is not nearly so extensive as if they were perpendicular to this plane. Owing to their double arthrodial joints, the ribs are movable on the spine; and their inferior extremity, also movable, rests either directly or indirectly on the sternum. Therefore it is that, when they are drawn forward by their middle portions, they pivot on their extremities, and tend to assume a perpendicular direction, which is the most favourable for the largest increase of the space they limit; then there is enlargement of the lateral diameter of the thorax, which signifies dilatation of its cavity. The inverse movement, by an opposite mechanism, causes contraction of the chest.

The ribs are said to be *elevated* during the forward movement, and *depressed* when they fall backwards. These expressions, though perfectly applicable to Man, who stands in a vertical position, are not correct when employed in veterinary anatomy.

Besides the enlargement of the thorax in the transverse and the antero-posterior directions, it is necessary to remark on an increase in a vertical direction, caused by the displacement of the sternum forward, due to elevation of the ribs. In this movement, the costal arches are erected not only on the median plane, but also on the spine. The inferior extremity, carried forward, also takes the sternum with it; and this movement cannot take place without that piece being farther removed from the vertebræ above. In Man, the displacement of the sternum is very marked.

Article IV.—Articulations of the Anterior Limbs.

1. Scapulo-humeral Articulation (Fig. 128).

(*Preparation.*—Detach the limb from the trunk. Remove from the upper extremity those muscles which are inserted in the vicinity of the glenoid cavity of the scapula; turn down from its lower extremity those which are inserted into the superior end of the humerus or a little below, preserving the attachments of their tendons with the capsular ligament. The scapulo-humeralis gracilis muscle may be allowed to remain, in order to show its relations.)

To constitute this enarthrodial articulation, the scapula is united to the humerus, and forms an obtuse angle which is open behind.

Articular surfaces.—In the scapula there is the glenoid cavity—the shallow, oval fossa, elongated in an antero-posterior direction, notched inwardly, and excavated at its centre, or near the internal notch, by a small synovial fossette. A ligamentous band, attached to the brim of the cavity, fills up this notch, and is the vestige of the glenoid ligament of Man. In the humerus, the articular head, fixed between the large and small tuberosities, is often excavated by a shallow synovial fossette.

Mode of union.—One *capsular ligament* (Fig. 128, 1), a kind of sac having two openings—one inferior, embracing the head of the humerus; and a superior, inserted into the margin of the glenoid cavity. This capsule presents, in front, two supporting fasciculi, which diverge as they descend from the coracoid process to the great and small tuberosities. The aponeurotic expansion thus formed is very thin and loose, so as to allow the two bones to separate to the extent of from $\frac{4}{10}$ to $\frac{8}{10}$ of an inch; but it is far from being sufficiently strong to bind them firmly together. The articulation is, therefore, strengthened by the powerful muscles which surround it, among which may be noticed: 1. In front, the coraco-radialis (flexor brachii), separated from the fibrous capsule by an adipose cushion. 2. Behind, the large extensor of the forearm and scapulo-humeralis gracilis (or teres minor) muscles, the use of which appears to be to pull up this capsule during the movements of flexion, so as to prevent its being pinched between the articular surfaces. 3. Outwards, the short abductor of the arm and the infra-spinatus (postea spinatus) tendon. 4. Inwards, the wide and strong tendon of the subscapularis muscle. In addition to this powerful retaining apparatus, there is the atmospheric pressure, the influence of which is of a certain importance. This may be proved by removing all the surrounding muscles, when it will be found that the capsule is not relaxed, nor are the articular surfaces separated; to effect this, it is necessary to make an opening in the capsule, so as to allow the air to enter its cavity, when the surfaces immediately fall apart.

Synovial capsule.—This is very loose, and entirely enveloped by the peripheral capsule, the internal surface of which it lines.

Movements.—Like all the enarthrodial articulations, the scapulo-humeral permits *extension*, *flexion*, *abduction*, *adduction*, *circumduction*, and *rotation*. These various movements, however, are far from being so extensive as in Man, the arm in the domesticated animals not being detached from the trunk, but, on the contrary, is fixed with the shoulder against the lateral parietes of the thorax. *Flexion* and *extension* are the least limited, and the most frequently repeated movements; their execution always demands a displacement of the two bones, which are almost equally movable. In *flexion*, the scapulo-humeral angle is closed, not only because the inferior extremity of the humerus is carried backwards and upwards, but also because the scapula pivots on its superior attachments in such a manner as to throw its glenoid angle forward and upward. *Extension* is produced by an inverse mechanism. During the execution of the other movements, the scapula remains fixed, and the humerus alone is displaced, bringing with it the inferior bones of the limb. If it is carried outwards, we have *abduction*, or inwards, *adduction*; if the leg passes successively from flexion to abduction, and from that to extension, etc., in describing a circle by its lower extremity, then there is *circumduction*; if it pivots from left to right, or right to left, we have *rotation*.

In the **Pig, Dog,** and **Cat,** the synovial membrane is not exactly enclosed by the fibrous capsule, but forms in front a *cul-de-sac*, which descends in the bicipital groove to favour the gliding of the coraco-radialis tendon.

In **Man,** the scapulo-humeral articulation is disposed as in animals, but it is also protected above by the coraco-acromion arch. For the reasons noted above, this articulation allows of more extensive motion than in animals. As remarked by Cruveilhier, of all the joints in the human body, the scapulo-humeral is that which has the most extensive motion; in movements forward and outward, the humerus can become horizontal; in those of circumduction it describes a complete cone, which is more extensive in front and laterally than behind and inwardly.

2. Humero-radial, or Elbow Articulation (Fig. 128).

(*Preparation.*—Turn down the inferior extremity of the flexors of the forearm, remove the olecranian, epicondyloid, and epitrochlean muscles, taking care not to damage the ligaments to which they somewhat closely adhere.)

Three bones concur to form this articulation, which presents a remarkable example of an angular ginglymus: the humerus, by its inferior extremity, and the two bones of the arm by their upper extremities.

Articular surfaces.—The *humeral surface*, already described at page 102, is transversely elongated, and convex from before to behind. It presents: 1. A median groove excavated by a synovial fossette. 2. An external groove (humeral trochlea) not so deep as the preceding. 3. A kind of voluminous condyle which borders, inwardly, the internal pulley, and whose antero-posterior diameter is much greater than that of the external lip of the trochlea of the opposite side. The *antibrachial* surface, divided into two portions, is moulded to the humeral surface; it is, therefore, concave before and behind, and is composed: 1. Of a double external groove. 2. Of an internal glenoid cavity, both excavated, on the superior extremity of the radius. 3. A middle ridge for the middle groove of the humerus, separating the two preceding surfaces, and prolonged on the ulnar beak, where it forms the sigmoid notch. This ridge shows a small synovial fossette hollowed out on the radius and ulna.

Mode of union.—Three ligaments: two lateral and an anterior.

a. The external lateral ligament (Figs. 128, 8) is a thick, short, and strong funicle, attached above to the crest limiting outwardly and posteriorly the musculo-spiral groove, and in the small cavity placed at the external side of the humeral articular surface. Below, it is inserted into the supero-external tuberosity of the radius. Its anterior border is confounded with the capsular ligament, and is margined by the principal extensor of the phalanges, which derives from it numerous points of attachment. By its posterior border it is in contact with the external flexor of the metacarpus. Its internal face is lined by synovial membrane, and its external face is only separated from the skin by the anti-brachial aponeurosis, and some of the fasciculi from the origin of the lateral extensor muscle of the phalanges. Its superficial fibres are vertical, and are continuous, behind, with the arciform ligamentous bands which stretch from the ulna to the radius. Its deep fibres are slightly oblique downwards and forwards.

b. The lateral internal ligament—also funicular—is longer, but not so strong as the preceding. It arises from the small tuberosity on the inner side of the superior articular face of the humerus, and, widening as it descends, reaches the radius. Its median fibres, which are the longest, are directed vertically downwards to reach the imprints situated below the bicipital tuberosity; its anterior fibres, curved forwards, are united to the tendon of the coraco-radialis muscle, or are confounded with the anterior ligament; the posterior are turned backwards, near their inferior extremities, to join the arciform fibrous fasciculi, which inwardly unite the ulna to the radius. The middle fibres of this ligament cover the inferior insertion of the short flexor of the forearm, and—in part only—that of the long flexor. It is covered by the ulna-plantar nerve and the posterior radial artery and vein.

Fig. 128.

SCAPULO-HUMERAL AND HUMERO-RADIAL ARTICULATIONS, WITH THE MUSCLES SURROUNDING THEM (EXTERNAL FACE).

1, Scapulo-humeral capsular ligament; 2, short abductor muscle of the arm; 3, its insertion in the humerus; 4, insertion of the infra-spinatus muscle on the crest of the great tuberosity; 5, coraco-radialis muscle; 6, its tendon of origin attached to the coracoid process; 7, its radial insertion confounded with the anterior ligament of the ulnar articulation; 8, 8, external lateral ligament of that articulation; 9, anterior ligament; 10, aconeus, or small extensor of the forearm; 11, origin of the external flexor muscle of the metacarpus; 12, short flexor muscle of the forearm. A, Tuberosity of the scapular spine; B, supra-spinous fossa; C, infra-spinous fossa; D, convexity of the small trochanter; E, summit of the trochanter.

c. The *anterior* or *capsular ligament* (Figs. 128, 9) is a membraniform band, attached by its superior border above the humeral articular surface, and by its inferior to the anterior margin of the radial surface. By its lateral borders, it is confounded with the funicular ligaments. Its internal half is formed of vertical fibres which descend from the humerus and expand over the radius, where they become united with the inferior tendon of the coraco-radialis muscle. In its external moiety it is extremely thin, and composed of fibres crossed in various directions. Lined internally by synovial membrane, this ligament is in contact, by its external surface, with the anterior radial vessels and nerves, the two flexor muscles of the forearm, the anterior extensor of the metacarpus, and the anterior extensor of the phalanges. The two latter muscles are even attached to it in a very evident manner. The elbow articulation, closed in front and on the sides by the three ligaments just described, has no particular ligaments posteriorly ; but it is powerfully strengthened there by the olecranian insertion of the extensor muscles of the forearm, and by the tendons of origin of the five flexor muscles of the metacarpus or phalanges.

Synovial membrane.—This membrane is very extensive, and, stretched out on the internal face of the before-mentioned ligaments, forms, behind, three great *culs-de-sac* of prolongment : a superior, occupying the olecranian fossa, and covered by a fatty cushion, as well as by the small extensor muscle of the forearm ;[1] two lateral, which descend from each side of the ulnar beak, and are distinguished as internal and external—the first lines the tendon of the external flexor of the metacarpus, the second facilitates the play on the upper radial extremity of the four flexor muscles of the foot or digits, and which are attached in common to the epitrochlea. This synovial sac also furnishes the radio-ulnar articulation with a diverticulum, which descends between the bones of the forearm to below the adjacent diarthrodial facets.

Movements.—*Flexion* and *extension.*

In *flexion*, the two bones do not approach each other directly, the inferior extremity of the radius deviating a little outwards. This is due more to the slight obliquity of the articular grooves, than to the difference in thickness between the external and internal extremities of the humeral surface.

Extension is limited by the reception of the beak of the olecranon in its fossa, and by the tension of the lateral ligaments ; so that the two bones cannot be straightened on one another in a complete manner, or placed on the same line.

In the **Dog** and **Cat**, the external lateral ligament is very thick, and forms in its inferior moiety a fibro-cartilaginous cap which is fixed on the ulna and radius, and united in front to the annular ligament of the superior radio-ulnar joint. This cap, with the last-named ligament, completes the osteo-fibrous ring in which the superior extremity of the radius turns. The internal lateral ligament is inserted, by two very short fasciculi, into the ulna and inner side of the head of the radius. A third fasciculus, deeper and median, much more developed than the first, and covered by the inferior insertion of the flexors of the forearm, descends between the radius and ulna to the posterior face of the former, and is there inserted near the inferior attachment of the external ligament, which it appears as if about to join.

In **Man**, the elbow articulation is formed nearly on the same plan as that of the Dog and Cat. The radius and ulna move together when the forearm is flexed and extended on the humerus.

3. Radio-ulnar Articulation.

Articular surfaces.—The two bones of the forearm articulate by diarthrodial and synarthrodial surfaces.

a. The diarthrodial surfaces consist of four undulated, transversely elongated facets, two of which are *radial* and two *ulnar*. The first border, posteriorly, the great articular surface forming the elbow-joint ; the second are situated beneath the sigmoid notch.

b. The *synarthrodial surfaces* are plane and roughened, and are also two on each bone : one, superior, extends below the diarthrodial facets to the radio-ulnar arch ; the other, inferior, more extensive, occupies all the anterior face of the ulna from this arch ; on the radius it forms a very elongated triangular imprint, which descends to the lower fourth of the bone (see pp. 104, 105).

[1] Some grey elastic fibres which cover this cul-de-sac externally, have been wrongly described as a posterior membraniform ligament.

Mode of union.—Two interosseous and two peripheral ligaments.

a. The *interosseous ligaments*, interposed between the synarthrodial surfaces, are composed of extremely short white fibres passing from one to the other surface, and which are endowed with a very remarkable power of resistance. The inferior always ossifies a long time before the animal is full grown—a circumstance which caused the older veterinary anatomists to describe—and with some show of reason—the radius and ulna as a single bone. Ossification of the superior ligament is very rare.

b. The *peripheral bands* are bundles of arciform fibres which, from the beak of the olecranon to the radio-ulnar arch, leave the lateral faces of the ulna to pass—some inwards, others outwards—to the posterior face of the radius. The fibres of the external ligament are confounded with the external humero-radial ligament. The internal fibres are united to the internal humero-radial ligament, and to the small ulnar tendon belonging to the short flexor of the forearm. Analogous fibres are found beneath the radio-ulnar arch; but they are much shorter and less apparent. (This is the *external transverse radio-ulnar ligament* of Leyh.)

Movements.—Very obscure in youth; nearly null when the two bones are fused together.

In the **Ox,** ossification of the superior interosseous ligament is constant at adult age.

In the **Dog** and **Cat,** we have already seen (p. 107) that the radius and ulna are not fused to each other, but remain independent during life. They are united in their middle portion by an interosseous ligament, and join by diarthrosis at their two extremities. These animals therefore exhibit; 1. *An interosseous ligament.* 2. A *superior radio-ulnar articulation.* 3. An *inferior radio-ulnar articulation.*

Interosseous ligament.—It is composed of very resisting white fibres, attached by their extremities to the bodies of the bones. Notwithstanding their shortness, they are loose enough to allow movements taking place between the radio-ulnar articulations.

Superior radio-ulnar articulation.—This is a trochoid articulation, which only allows movements of rotation or pivoting.

The *articular surfaces* which form this articulation are: in the ulna, the small sigmoid cavity—a surface excavated in the lateral sense, and semicircular; in the radius, a cylindrical half-hinge received into the preceding cavity.

To unite these there is an *annular ligament*—a kind of fibrous web thrown around the superior extremity of the radius, fixed inwardly on the ulna near the inner extremity of the small sigmoid cavity, attached outwardly to the external lateral ligament of the elbow articulation, and confounded superiorly with the anterior ligament of the same articulation. This fibrous web, in uniting with the fibro-cartilaginous cap of the external humero-radial ligament, and joining the small sigmoid cavity by its internal extremity, transforms this last into a complete ring, covered with cartilage in its bony portion. The head or superior extremity of the radius is also encrusted, over its entire contour, with a layer of cartilage—a condition which permits it to glide not only in the concave face of the small sigmoid cavity, but also on the internal face of the two ligaments which complete this cavity.

Inferior radio-ulnar articulation.—This is also a trochoid articulation analogous to the preceding, but inversely disposed. Thus, the concave articular surface is hollowed on the radius, outside the inferior extremity; the convex surface lies within the ulna. These two facets are very small, and are maintained in contact by a diminutive peripheral fibrous capsule. A strong interosseous ligament, situated beneath the articular facets, also consolidates this diathrosis, and concurs by its inferior border to form the antibrachial surface of the radio-carpal articulation. A small synovial capsule is specially devoted to this articulation.

Mechanism of the radio-ulnar joints.—The play of these two articulations is simultaneous, and tends to the same end—that is, to the execution of the double rotatory movement which constitutes *supination* and *pronation.*

Supination is when the ulna remains fixed, and the radius pivots on it in such a manner as to carry its anterior face outwards. Its superior extremity then turns from within forwards—and even from before outwards if the movement is exaggerated, in the articular girdle formed by the small sigmoid cavity of the ulna and the ligaments which complete it. The inferior extremity also rolls on the ulnar facet in describing a similar movement, and the internal tuberosity of this extremity is carried forwards.

In the movement of *pronation*, this tuberosity is brought inwards, and the anterior face of the radius comes forward by an opposite mechanism.

The inferior bone of the anterior limb being articulated in a hinge-like manner with the radius, it follows this bone in its rotatory movements, the anterior face of the metacarpus looking outwards during supination and forwards in pronation.

The radio-ulnar articulation in **Man** resembles that of the Dog and Cat, the articular surfaces only being larger and the movements more extensive. In supination, the palmar face is turned forward, and the radius, situated on the outer side of the ulna, is in the same direction as the latter. In pronation, on the contrary, the palmar face of the hand looks backwards, and the radius—remaining outwards in its upper part—crosses the ulna in front in such a manner that its lower extremity is placed within the ulna.

4. Articulations of the Carpus (Figs. 129, 130)

Preparation.—After removing the tendons surrounding the carpus, the ligaments common to all the carpal articulations can be studied. The anterior and posterior membraniform ligament can then be removed, and the ligaments proper to each row, as well as those uniting the two rows, and these to adjoining bones, can be dissected. Some time is required for this dissection, which is not difficult.

These comprise: 1. The articulations uniting the carpal bones of the first row to each other. 2. The analogous articulations of the second row. 3. The radio-carpal articulation. 4. The articulation of the two rows with each other. 5. The carpo-metacarpal articulation.

Articulations which unite the Bones of the First Row to each other.—These bones, four in number, are joined by the diarthrodial facets on their lateral faces, and form small arthrodial articulations.[1] They are maintained in contact by six ligaments, *three anterior*, and *three interosseous*. The *anterior ligaments* are small flattened bands carried from the fourth bone to the first, from the first to the second, and from that to the third. The first, placed outside rather than in front of the carpus, is covered by the external lateral ligament and the inferior tendon of the external flexor of the metacarpus; the others adhere to the capsular ligament. The *interosseous ligaments* are implanted in the grooves of insertion which separate the diarthrodial facets. One of them, derived from the common superior ligament, unites the first to the second bone. The two others, situated between the three last carpal bones, are confounded with the corresponding anterior ligaments.

Articulations uniting the Carpal Bones of the Second Row.—These are arthrodial articulations, like the preceding, but numbering only two. They are fixed by *two anterior* and *two interosseous ligaments*. One of the *anterior ligaments* joins the first bone to the second, and strongly adheres to the capsular ligament; the other is entirely covered by the lateral internal ligament, and attaches the two last bones to each other. Of the two *interosseous ligaments*, the second alone is confounded with the corresponding anterior ligament. That which is situated between the two first bones is separated from the anterior ligament by one of the diarthrodial facets between these bones.

Radio-carpal Articulation.—The inferior extremity of the radius, in becoming united to the upper row of carpal bones, constitutes a diarthrosis which, from the nature of the movements it permits, may be considered as an imperfect hinge-joint.

[1] The facet uniting the supercarpal to the first bone is not situated on one of its faces, but rather on the anterior part of its circumference.

Articular surfaces.—The radial surface, elongated transversely and very irregular, presents : 1. Outwardly, a wide groove, limited in front by a small glenoid cavity, and bounded, posteriorly, by a non-articular excavation which receives a prolongation of the second bone in the movement of flexion ; 2, Inwardly, a condyle with a more extensive curvature than that of the preceding groove, and, like it, completed by a small anterior glenoid cavity. The carpal surface, moulded exactly on the radial, offers depressions corresponding to the projections on it, and *vice versâ*.

Mode of union.—The radio-carpal articulation is bound by three ligaments which entirely belong to it ; and by four strong ligaments that are common to it and articulations which will be studied hereafter.

Of the *three ligaments proper* belonging to the radio-carpal articulation, one forms a thick, rounded funicle, extending from the radius to the fourth bone in an oblique direction downwards and inwards, and concealed by the common posterior ligament. The second (Fig. 130, 5), much smaller, is carried from the supercarpal bone to the external side of the inferior extremity of the radius, and is partly covered by the common external ligament. When the synovial capsule is distended by dropsy, it may form a hernia at the outer side of the carpus, by passing between this small ligament and the common posterior ligament. The third, very delicate, but always present, is deeply situated beneath the last ; it is inserted, for one part, into the radius near the first proper ligament, and for the other, into the second bone and the interosseous ligament which unites the supercarpal to that bone.

Synovial membrane.—After lining these three ligaments, and the four great ligaments yet to be described, this membrane is prolonged between the three first carpal bones, to cover the superior face of the interosseous ligaments which unite them. It even more frequently descends into the articulation which joins the supercarpal to the first bone ; though it also sometimes happens that this has a particular synovial capsule of its own.

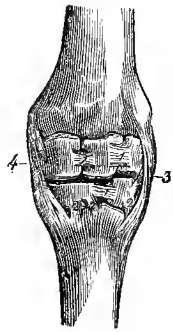
ARTICULATION OF THE TWO ROWS BETWEEN EACH OTHER.—Like the preceding, this is an imperfect hinge articulation.

Articular surfaces.—These are two, and are both transversely elongated, very irregular in their configuration, and divided into three portions. The inferior shows : behind, three small condyles placed side by side ; in front, two slightly concave facets. The superior corresponds to the first by three glenoid cavities and two convex facets.

Mode of union.—For this articulation, besides the common great ligaments, there are *three particular ligaments.* Two of these are very short, and are situated behind the carpus, underneath the great common posterior ligament. They are readily perceived by removing the capsular ligament, and strongly flexing the carpus. "The strongest extends vertically from the internal bone of the superior row to the second and third bones of the metacarpal row ; the other descends obliquely from the first bone of the antibrachial row to the second of the inferior row" (Rigot). The third ligament proper, much stronger than the other two, reaches from the supercarpal to the first bone of the inferior row and the head of the external metacarpal bone. It is confounded, outwardly, with the great external lateral ligament ; inwardly, with the common posterior ligament. Its posterior border gives attachment to the fibrous arch which completes the carpal sheath. This ligament has also a branch which is fixed on the second bone of the upper row (Fig. 130, 4).

Synovial membrane.—This lines all the ligaments, and is prolonged above and below, between the carpal bones, to facilitate the gliding of their articular facets. Two upper prolongations ascend between the three first bones of the antibrachial row, to cover the inferior face of the interosseous ligaments uniting them. Two other prolongations descend between the carpal bones of the second row; the external, after covering the first interosseous ligament, passes between it and the corresponding anterior ligament, and communicates with the synovial capsule of the carpo-metacarpal articulation. The internal forms a *cul-de-sac* which rests on the interosseous ligament.

Fig. 129.



CARPAL ARTICULATIONS (FRONT VIEW).

1, 1, Anterior ligaments uniting the carpal bones of each row; 2, 2. anterior ligaments proper to the carpo-metacarpal articulation; 3, common external ligament; 4, common internal ligament.

CARPO-METACARPAL ARTICULATION.—The carpal bones of the second row articulate with the superior extremity of the metacarpal bones, constituting a plaiuform diarthrosis.

Articular surfaces.—These are, on each side, plane facets more or less inclined one on the other, and continued between each other. The largest is in the middle, and is generally hollowed by a small, shallow, synovial fossette.

Mode of union.—There are the four great common ligaments, and also *six special ligaments: two anterior, two posterior,* and *two interosseous.*

Of the *two anterior ligaments* (Fig. 129, 2, 2), one is divided into two distinct bands, and unites the second bone to the principal metacarpal; the other, concealed by the external lateral ligament, attaches the first bone to the head of the external metacarpal bone.

The two posterior ligaments described by Rigot do not appear to us to be sufficiently distinct from the great ligament to merit a special description.

The *two interosseous ligaments*, completely overlooked by that able anatomist, start from the interstices which separate the median metacarpal bone from the lateral metacarpals, and join the interosseous ligaments of the second row; they are thick and short. We have sometimes noted one or other of them to be absent.

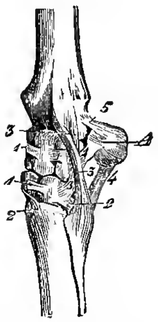
Synovial membrane.—This communicates, as indicated above, with the synovial capsule of the preceding articulation. It furnishes a superior *cul-de-sac*, which rests on the interosseous ligament interposed between the two last carpal bones of the second row. Two inferior *culs-de-sac* descend into the intermetacarpal arthrodial articulations.

LIGAMENTS COMMON TO THE THREE PRECEDING ARTICULATIONS.—As before mentioned, these are four in number: two lateral, one anterior, and one posterior.

a. The external lateral ligament (Figs. 129, 3; 130, 3) is a thick funicular cord composed of two orders of fibres—a deep-seated and a superficial order, slightly crossed. It leaves the external and inferior tuberosity of the radius, descends vertically to the side of the carpus, transmits a fasciculus to the first bone of the upper row, gives off another fasciculus which stops at the external bone of the second row, and terminates on the head of the corresponding metacarpal bone. Traversed obliquely by the lateral extensor of the phalanges, this ligament covers the external carpal bones. In front, it is united to the capsular ligament; near its inferior extremity, it is confounded with the strong ligament which joins the supercarpal bone to the first bone of the inferior row and to the head of the external metacarpal bone.

b. The *internal lateral ligament* (Fig. 129, 4), analogous to the preceding and situated on the opposite side, is wider and thicker than it. It commences on the internal tuberosity of the radius, and terminates on the upper extremity of the middle and internal metacarpal bones, after being attached, by two distinct fasciculi, to the third carpal bone of the upper row, and the two last of the metacarpal row. In contact by its external face with the tendon of the oblique extensor muscle of the metacarpus, this ligament responds, by its deep face, to the synovial membranes of the carpus and to the bones to which it is attached. By its anterior border it is united to the capsular ligament ; the opposite border is intimately confounded with the posterior ligament, from which it is impossible to distinguish it.

Fig. 130.



LATERAL VIEW OF THE CARPAL ARTICULATIONS.

1, 1, Anterior ligaments uniting the two rows of carpal bones; 2, 2, anterior ligaments proper to the carpo-metacarpal articulation; 3, common external ligament; 4, one of the ligaments proper to the articulation of the two rows (metacarpo-supracarpal); 5, one of the ligaments proper to the radio-carpal articulation (radio-supercarpal). A, Groove on the external surface of the supercarpal bone, for the passage of the external flexor of the metacarpus.

c. The *anterior*, or *capsular ligament*, is a membranous band covering the anterior face of the carpal articulations. Its superior border is attached to the radius ; the inferior is inserted into the superior extremity of the principal metacarpal bone. The two right and left borders are united with the lateral ligaments. Its external face is in contact with the tendons of the anterior extensor muscles of the metacarpus and phalanges. The internal face is lined at certain points by synovial membrane, and adheres in others to the carpal bones and the anterior ligaments binding these to one another. This ligament is composed of transverse fibres more or less oblique, and arranged crosswise ; by its amplitude it can adapt itself to the movements of flexion of the knee.

d. The *posterior ligament*, one of the strongest in the animal economy, covers the posterior face of the carpus, filling up the asperities which roughen it. It is inserted : above, on the transverse crest surmounting the articular surface of the radius ; by its middle portion into all the carpal bones ; below, into the head of the principal metacarpal bone. Confounded inwardly with the internal lateral ligament, united outwardly to the band which attaches the supercarpal to the external metacarpal and the second carpal bone of the upper row, this ligament is continued, by its inferior extremity, with the carpal stay (or check ligament) which sustains the perforans tendon. Its posterior face is perfectly smooth, and is covered by the synovial membrane of the carpal sheath.

Movements of thf Carpal Articulations.—The carpus is the seat of two very extensive and opposite movements—*flexion* and *extension ;* to which are added three very limited accessory movements—*adduction*, *abduction*, and *circumduction*.

All the carpal articulations do not take an equal part in the execution of these movements ; for it is easy to discover that they are chiefly performed in the radio-carpal diarthrosis, and in the imperfect hinge articulation uniting the two rows of carpal bones. Each of these articulations participates in the movements of the carpus in nearly the same proportions, and both act in an identical manner. Their mechanism is most simple.

In *flexion*, the first tier of bones rolls backwards on the radius, the inferior row moves in the same sense on the upper, the metacarpus is carried backwards and upwards, the common posterior ligament is relaxed, the capsular ligament becomes tense, and the articular surfaces, particularly those of the second joint, separate from each other in front. In *extension*, the metacarpus is carried downwards and forwards by an inverse mechanism. This movement stops when the ray of the forearm and that of the metacarpus are in the same vertical line. In flexion, these bones never directly approach each other, the inferior extremity of the metacarpus being always carried outwards. It may also be remarked, that the slight movements of *abduction*, *adduction*, and *circumduction* of the carpus are only possible at the moment when the foot is flexed on the forearm.

With regard to the planiform diarthroses articulating the carpal bones of the same row, they only allow a simple gliding between the surfaces in contact; and with the carpo-metacarpal arthrodia it is absolutely the same. The restricted mobility of these various articulations has but a very secondary influence on the general movements of the carpus; but it nevertheless favours them by permitting the carpal bones to change their reciprocal relations, and adapt themselves, during the play of the radio-carpal and intercarpal hinges, to a more exact coaptation of the articular planes which they form.

In the other animals, the carpal articulations have the same essential characteristics we have noticed in Solipeds. The four principal peripheral bands differ but little in them; though in the **Dog** and **Cat** they are lax enough to allow somewhat extensive lateral movements.

5. Intermetacarpal Articulations.

Each lateral metacarpal bone articulates with the middle one, by means of diarthrodial and synarthrodial surfaces, for the description of which refer to page 112. An interosseous ligament, composed of very short and strong fasciculi, is interposed between the synarthrodial surfaces, and binds them firmly together. Its ossification is not rare. The diarthrodial facets are maintained in contact by the preceding ligament, and by the carpal ligaments inserted into the head of the lateral metacarpal bones. The intermetacarpal articulations only allow a very obscure, vertical, gliding movement.

In the **Ox**, there is only one intermetacarpal articulation, which is much simpler than those in the Horse.

In the **Pig**, the four metacarpal bones correspond, at their upper extremity, by means of small diarthrodial facets on their sides. Fibrous fasciculi, derived from the great anterior and posterior ligaments of the carpus, protect these intermetacarpal articulations before and behind. Other fibres, situated between the adjacent faces of the metacarpal bones, are real interosseous ligaments.

In the **Dog** and **Cat**, the four great metacarpal bones articulate with each other in almost the same manner as in the Pig, but their mobility is greater

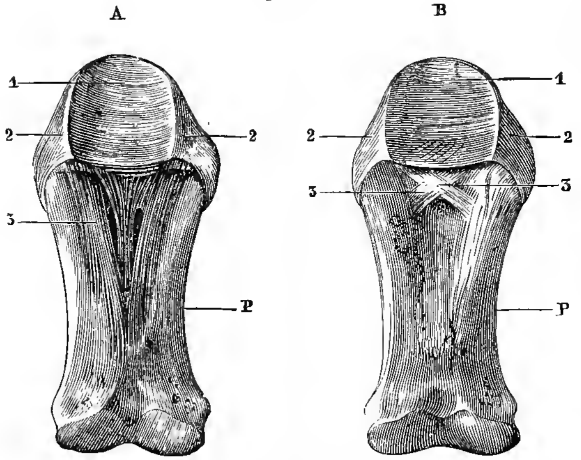
6. Metacarpo-phalangeal Articulation (Figs. 131, 132).

Preparation.—In order to study the whole of this articulation, it is well to have an anterior limb from the lower fourth of the forearm. From this the tendons of the flexors and extensors of the phalanges are to be removed, and then the suspensory ligament of the fetlock, anterior capsular ligament, lateral ligaments, and the superficial inferior sesamoid ligament, can be dissected. To study the ligaments which bind the bones forming the inferior articular surface, the first phalanx and sesamoid bones should be removed, which allows of the dissection of the inter-, lateral, and inferior sesamoid middle and deep ligaments. An injection of the synovial capsule brings into relief some features which are interesting, from a surgical point of view.

This is a perfect hinge-joint, formed by the inferior extremity of the median metacarpal bone on the one part, and the superior extremity of the upper phalanx and sesamoids on the other.

Articular surfaces.—For the metacarpal bone, there are two lateral condyles and a median antero-posterior eminence; for the first phalanx, two glenoid cavities and an intermediate groove prolonged posteriorly on the anterior face of the two sesamoids. Divided in this manner into three portions, the digital surface is well constituted for solidity, because the pressure transmitted to this region is diminished and diffused by the natural elasticity of the bands which unite these three pieces to each other.

Fig. 131.



DETAILS OF THE METACARPO-PHALANGEAL ARTICULATION OF THE HORSE.

A. Middle inferior sesamoidean ligaments. P. First phalanx (posterior face). 1, Inter sesamoidean ligament (posterior face); 2, 2, lateral sesamoidean ligaments; 3, middle inferior sesamoidean ligament.

B. Deep inferior sesamoidean ligaments. P. First phalanx: 1, Inter-sesamoidean ligament; 2, 2, lateral sesamoidean ligaments; 3, inferior deep sesamoidean ligament.

Mode of union.—The means of union may be divided into two categories: 1. Those which join together the several bones of the inferior surface. 2. Those which maintain in contact the two opposed articular surfaces.

A. The first have received the generic name of *sesamoid ligaments*, and are six in number: an *intersesamoid ligament*, which holds together the two complementary bones of the digital surface; *three inferior* and *two lateral sesamoid ligaments*, which unite these bones to the first phalanx.

a. The *intersesamoid ligament* is composed of fibro-cartilaginous substance, that appears to be the matrix in which the two sesamoids were developed; as it is spread around these bones, after being solidly fixed on their internal face. Behind, this ligament, in common with the posterior face of the sesamoids, forms the channel (Fig. 131, 5) in which the flexor tendons glide. In front, it occupies the bottom of the intersesamoid articular groove.

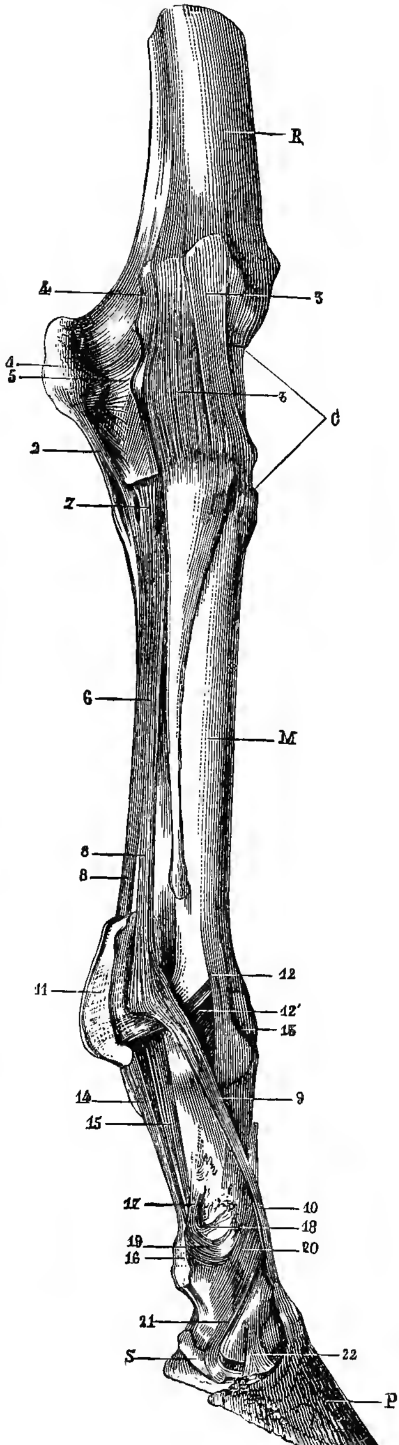
b. The *inferior sesamoid ligaments*, situated at the posterior face of the first phalanx, are distinguished as superficial, middle, and deep.

The *superficial ligament* (Figs. 131, 14; 134, 8), the longest of the three, is a narrow band flattened before and behind. It arises from the middle of the fibro-cartilaginous mass which completes, posteriorly, the superior articular surface of the second phalanx, and, slightly widening, ascends to the base of the sesamoids, into which it is inserted by becoming confounded with the intersesamoid ligaments. Its posterior face, lined by the synovial membrane of the so-called sesamoid sheath, is covered by the flexor tendons; it partly covers the middle ligament.

The *middle ligament*, triangular and radiating, is composed of three particular fasciculi: two lateral (seen on each side of the superficial ligament in Fig. 131, A 3), and a median which has been generally confounded with the superficial ligament, although it is clearly distinguished from it by its inferior insertion. Fixed in common to the posterior imprints of the first phalanx, these three fasciculi diverge in ascending to the base of the sesamoids, where they have their upper insertion.

The *deep ligament* is constituted by two small bands concealed beneath the middle ligament. Thin, short, flattened before and behind, and intercrossed (Fig. 131, B 3), these bands are fixed to the base of the sesamoids in one direction, and in the other to the superior extremity of the first phalanx, near the margin of its articular surface. This ligament is covered on its anterior face by the synovial membrane of the articulation.

Fig. 132.



CARPAL, METACARPAL, AND INTER-PHALANGEAL ARTICULATIONS OF THE HORSE (POSTERO-LATERAL VIEW).

R, Radius; C, carpus; M, metacarpus; S, navicular bone; P, third phalanx. 1, Supercarpal bone; 2, its proper ligament; 3, external lateral ligament of the carpal articulations (superficial layer); 3, ditto (deep layer); 4, groove for the tendon of the external flexor of the metacarpus; 5, common posterior ligament of the carpal articulations; 6, superior sesamoidean, or suspensory ligament of the fetlock; 7, an originating branch of ditto; 8, 8, terminal branches of ditto; 9, band given off by ditto to the anterior extensor of the phalanges; 10, tendon of the anterior extensor of the phalanges; 11, groove formed by the posterior face of the intersesamoidean ligament; 12, lateral metacarpo-phalangeal ligament (superficial layer); 12′, ditto (deep layer); 14, inferior superficial sesamoidean ligament; 15, ditto (deep layer); 16, glenoidal fibro-cartilage of the second phalanx; 17, 18, 19, superior, middle, and inferior bands of that fibro-cartilage; 20, lateral ligament of the first inter-phalangeal articulation; 21, lateral posterior ligament of the second inter-phalangeal articulation; 22, anterior lateral ligament of ditto.

c. The *lateral sesamoid ligaments* are two thin layers, extending from the external face of each sesamoid to the tubercle of insertion on the side of the superior extremity of the first phalanx (Fig. 131, A 2). They are covered by the digital vessels and nerves, by the fibrous stay detached from the suspensory ligament to the anterior extensor tendon of the phalanges, and by the superficial fasciculus of the lateral metacarpo-phalangeal ligament; they are covered by synovial membrane on their internal face.

B. The ligaments destined to unite the two articular surfaces of the metacarpo-phalangeal joint are four: *two lateral*, *one anterior*, and *one posterior*.

a. Each *lateral ligament* comprises two fasciculi—a superficial and a deep—firmly united by their adjacent faces. The superficial fasciculus (Fig. 132, 12) commences on the button of the lateral metacarpal bone, attaches itself to the median metacarpal, and descends vertically to terminate at the superior extremity of the first phalanx. It covers the phalangeal insertion of the lateral sesamoid ligament and the deep fasciculus. The latter, attached superiorly in the lateral excavation of the inferior extremity of the principal metacarpal, radiates as it reaches the sesamoid and the superior extremity of the first phalanx, where it is fixed by mixing its fibres with those of the lateral sesamoid ligament. The inner face of this fasciculus is lined by the articular synovial membrane (Fig. 132, 12′).

b. The anterior ligament (Fig. 132) belongs to the class of capsular ligaments. It is a very resisting membraniform expansion, which envelops the anterior face of the articulation. Attached by its upper border to the anterior margin of the metacarpal surface, and by its inferior border to the first phalanx, this expansion is confounded at its sides with the lateral ligaments. It is covered by the extensor tendons of the phalanges, which glide on its surface by means of small serous sacs. Its internal face adheres throughout its whole extent to the synovial capsule.

c. The *posterior ligament*,[1] very appropriately named the *suspensory ligament of the fetlock* (Figs. 132, 6; 133, 134, 4), is a long and powerful brace, composed of white fibrous tissue, and often containing fasciculi of fleshy fibres in its texture. Lodged behind the median metacarpal, and between the two lateral metacarpal bones, this brace is quite thin at its origin, but it soon becomes enlarged, and preserves its great thickness to the extent of its upper fourth. Examined in section, it appears to be formed of two superposed portions which are closely adherent to each other. The superficial portion, the thinnest, commences by three small branches, which are fixed to the first and second bones of the lower carpal row (Figs. 132, 133, 5); the deep portion, much thicker, is attached to the posterior face of the principal metacarpal for about $\frac{8}{10}$ of an inch. It has been wrongly asserted that the suspensory ligament of the fetlock is continuous with the common posterior ligament of the carpus; it is, on the contrary, quite distinct from it. The carpal stay (*deep palmar aponeurosis* of Man) is alone in direct continuity with the common posterior ligament of the carpus (133, 3). The suspensory ligament of the fetlock is bifid at its inferior extremity; its two branches, after being fixed into the summits of the sesamoid bones, give origin to two fibrous bands which pass downwards and forwards to become united on each side to the anterior extensor tendon of the phalanges (Fig. 132, 9). It is in relation, by its posterior face, with the perforans tendon and its carpal stay; by its anterior face, with the median metacarpal bone, and arteries and veins; by its borders,

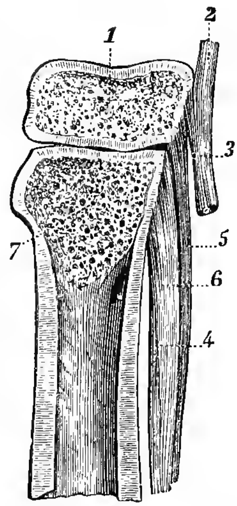
[1] It corresponds to the two muscles which, in *Man*, lie alongside the interosseous metacarpal muscles. (See Muscles of the Foot.)

with two small interosseous muscles, the lateral metacarpal bones, and the digital vessels and nerves.

Synovial membrane.—This membrane is prolonged as a *cul-de-sac* between the terminal branches of the preceding ligament. It is the distension of this sac which causes the articular swellings vulgarly designated "windgalls."

Movements.—The metacarpo-phalangeal articulation permits the *extension* and *flexion* of the digit, and some slight lateral motion when the movable osseous segment is carried to the limits of flexion.

Fig. 133.



SECTION OF THE INFERIOR ROW OF CARPAL BONES, THE METACARPAL, AND THE SUSPENSORY LIGAMENT OF THE FETLOCK.

1, Os magnum; 2, common posterior ligament of the carpus; 3, stay, or band for the perforans tendon, 4, suspensory ligament of the fetlock; 5, its superficial layer; 6, its deep fasciculus; 7, principal metacarpal bone.

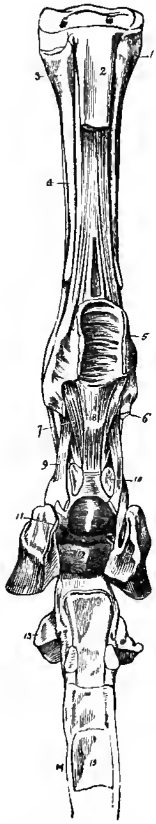
In the **Ox, Sheep,** and **Goat,** this articulation constitutes a double hinge, which resembles the simple ginglymus of Solipeds. They have *three intersesamoid ligaments:* two lateral, to unite the large sesamoids of each digit; and a median, which unites the internal sesamoids. The *inferior sesamoidean ligamentous apparatus* is far from showing the same degree of development as in the Horse. It is reduced for each digit to four small bands, which remind one very much of the deep ligament of the latter animal, as it has been described by Rigot: two lateral bands pass directly from the sesamoids to the upper extremity of the first phalanx; the other two, situated between the first, intercross and are confounded with the latter by their extremities. A *lateral sesamoid ligament* unites the first phalanx to the external sesamoid.

For each digit there are *two lateral metacarpo-phalangeal ligaments*—an external, analogous to that of the Horse, but less complicated, is attached by its inferior extremity to the first phalanx only; the other, internal, fixed superiorly in the bottom of the inter-articular notch of the metacarpal bone, is inserted into the inner face of the first phalanx in mixing its fibres with those of the *superior interdigital ligament.* This latter is situated between the two first phalanges, and is composed of short, intercrossed fibres, attached to the imprints which in part cover the internal face of the two first phalangeal bones. In the **Sheep** there are only traces of this interdigital ligament, and each internal metacarpal-phalangeal gives rise, near its phalangeal insertion, to a fibrous branch which is directed backwards from the interdigital space, and is terminated in the bone of the ergot (or posterior rudimentary digit), which it sustains. The *anterior* or *capsular ligament,* single as in Solipeds, unites the two external lateral ligaments. The *suspensory ligament,* single superiorly, is divided inferiorly into eight branches, two of which are joined to the perforatus tendon, to form with it the double ring through which the two branches of the perforans pass. Four other branches, in pairs, extend to the summits of the sesamoids. That which is sent to each external sesamoid gives off, on the side of the first phalanx, a reinforcing band to the proper extensor of the digit. The two last, profound and median, descend into the inter-articular notch of the metacarpal bone, after becoming a single fasciculus; afterwards, they pass between two internal metacarpo-phalangeal ligaments, and separate from each other in passing downwards and forwards on the inner side of the first phalanx, to join the proper extensor tendon of each digit.

In the **Pig, Dog,** and **Cat,** for each metacarpo-phalangeal there is: a proper synovial membrane; an intersesamoid ligament; an inferior sesamoid ligament composed of two cross-bands; two small lateral sesamoid ligaments; two lateral metacarpo-phalangeal ligaments, attached inferiorly to the first phalanx and the sesamoids; an anterior capsular ligament, in the centre of which is found a small bony nucleus—a kind of anterior sesamoid—over which glides one of the branches of the common extensor of the digits. The suspensory ligament is replaced by real palmar interosseous muscles (see the Muscles of the Anterior Foot). Some fibres situated between the first phalanges in the great digits of the Pig, resemble the superior interdigital ligament of the Ox.

In **Man,** the cavity in the upper extremity of the first phalanx is completed by a glenoid ligament. The glenoid ligaments of the four first digits are united to each other by a transverse ligament of the metacarpus. The articulations are consolidated by two lateral ligaments. The metacarpo-phalangeal articulations allow flexion and extension movements, as well as those of abduction and adduction; but the latter are limited by the lateral ligaments.

Fig. 134.



POSTERIOR VIEW OF THE METACARPO-PHALANGEAL AND INTER-PHALANGEAL ARTICULATIONS (RIGHT LIMB).

1, 3, Outer and inner rudimentary metatarsal bones; 2, perforans tendon and its check ligament; 4, suspensory ligament; 5, gliding surface or sheath for the flexor tendons, formed by the posterior face of the sesamoid bones, and intersesamoid, transverse, and annular ligaments; 6, section of lateral sesamoid ligament; 7, lateral fasciculus of the middle inferior sesamoid ligament; 8, inferior superficial sesamoid ligament; 9, lateral ligament of the first interphalangeal articulation; 10, section of the terminal branch of the perforatus tendon; 11, section of the lateral cartilage of the foot; 12, postero-inferior surface of navicular bone; 13, section of lateral cartilage, plantar cushion, and wing of pedal bone; 14, perforatus tendon, 15, perforans tendon.

7. Articulation of the First with the Second Phalanx, or First Interphalangeal Articulation.

(*Preparation.*—Remove the extensor tendon; throw open the metacarpo-phalangeal sheath, and turn down the flexor tendons.)

This is an imperfect hinge-joint.

Articular surfaces.—On the inferior extremity of the first phalanx are two lateral condyles, separated by a groove. On the superior surface of the second phalanx are two glenoid cavities, and an antero-posterior ridge.

The latter surface is completed behind by a *glenoidal fibro-cartilage*, very dense and thick (Fig. 132, 16), which also acts as a ligament. It is attached, in one direction, to the second phalanx, between the superior articular surface and the kind of fixed sesamoid which margins it behind; in the other, it is inserted into the first phalanx by means of six fibrous bands (Fig. 135, 4, 5, 6): two superior, which embrace the inferior, middle, and superficial sesamoid ligaments; two middle, and two inferior, which extend to the sides of the inferior extremity of the first phalanx. This fibro-cartilage is moulded, in front, to the articular surface of the latter bone, and forms, by its posterior face, a gliding surface for the perforans tendon (Figs. 132, 16; 134, 5). It is confounded, laterally, with the two branches of the perforatus, and receives, in the middle of its superior border, the insertion of the inferior superficial sesamoid ligament.

Mode of union.—*Two lateral ligaments* (Fig. 135, 7), to which are added, behind, the fibro-cartilage just described, and in front the tendon of the anterior extensor of the phalanges. These ligaments are large and thick, and, passing obliquely downwards and backwards, are inserted, superiorly, into the lateral tubercles of the inferior extremity of the first phalanx. They are attached, beneath, to the sides of the second phalanx. Their most inferior fibres are even prolonged below that point to reach the extremities of the navicular bone, and constitute the posterior lateral ligaments of the pedal articulation.

Synovial membrane.—This covers the tendon of the anterior extensor of the phalanges, the lateral ligaments, and the glenoid fibro-cartilage. Behind, it forms a *cul-de-sac*, which extends between the latter and the posterior face of the first phalanx (Fig. 137).

Movements.—This imperfect hinge is the seat of two principal movements: *extension* and *flexion*. It also allows the second phalanx to *pivot* on the first, and permits some *lateral movements*.

In the **Ox, Sheep,** and **Goat,** the glenoid fibro-cartilage is confounded with the perforatus tendon, and is only attached to the first phalanx by two lateral bands. The internal lateral ligament comprises two fasciculi: one, very short, which terminates in the second phalanx; and another, very long, descending to the internal face of the third phalanx. The external is very thin, and is also prolonged to the terminal phalanx; so that the two last interphalangeal articulations of each digit are fixed by two common lateral ligaments which correspond exactly, by their position and inferior attachments, to the anterior lateral ligaments of the pedal joint of Solipeds.

In the **Dog** and **Cat,** the glenoid cartilage, also confounded by its posterior face with the perforatus tendon, only adheres to the first phalanx by some cellular bands. The two lateral ligaments pass from the inferior extremity of the first phalanx to the superior extremity of the second.

In the **Pig,** there is somewhat the same arrangement as in Carnivora. The external lateral ligament is, nevertheless, more like that of the Horse, in its most anterior fasciculi being prolonged to the external extremity of the navicular bone.

8. Articulation of the Second Phalanx with the Third, Second Interphalangeal Articulation, or Articulation of the Foot.

Preparation.—Remove the hoof according to the directions given hereafter, when treating of the muscles of the forearm; then the plantar cushion, the flexor tendons, and one of the lateral cartilages. A section like that shown in Fig. 137 is useful to show the relations between the synovial capsule of this joint and the bursæ, behind the second phalanx.

To form this imperfect hinge-joint, the second phalanx is opposed to the third, and to the navicular bone.

Articular surfaces.—On the inferior face of the second phalanx there are two lateral condyles and a median groove. On the superior face of the third phalanx and the navicular bone, are two glenoid cavities separated by an antero-posterior ridge. The two bones which form this last surface, articulate with each other by arthrodia; the navicular bone presents for this purpose an elongated facet on its anterior border; the os pedis also offers an analogous facet on the posterior contour of the principal articular surface.

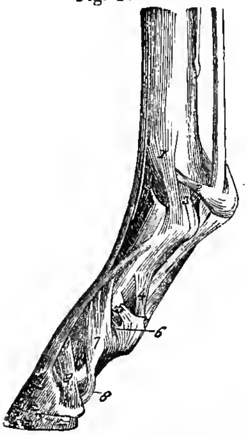
Mode of union.—Five ligaments: a single interosseous one, which joins the navicular to the pedal bone; and four lateral bones, distinguished as anterior and posterior.

a. Interosseous ligament (Fig. 136, 2).—This is formed of very short fibres, which are inserted, behind, into the anterior groove of the navicular bone; and in front, into the posterior border and inferior face of the third phalanx. This ligament is lined, on its superior surface, by the synovial membrane, and on its inferior face is covered by the navicular sheath.

b. Anterior lateral ligaments (Figs. 132, 22; 135, 9).—These are two thick, short, and wide fasciculi, attached by their superior extremities to the lateral imprints of the second phalanx, and by their inferior extremities into the two cavities at the base of the pyramidal eminence of the os pedis. Each ligament is partly covered by the complementary fibro-cartilage of that bone, and appears to form a portion of it. Its anterior border is continuous with the common extensor tendon of the phalanges; its internal face is covered by the synovial membrane, which adheres closely to it.

c. Posterior lateral ligaments (Figs. 132, 21; 135, 8).—These have been already noticed. Each is composed of the lowermost fibres of the lateral ligament of the first interphalangeal articulation; these fibres, after being attached to the second phalanx, unite into a sensibly elastic fibrous cord, which is chiefly fixed into the extremity and superior border of the navicular bone, where the ligaments join each other, and in this way form a kind of complementary cushion that increases the navicular articular surface. It also sends off a short fasciculus to the retrossal process, and a small band to the internal face of the lateral fibro-cartilage. Partly concealed by the latter and the plantar cushion, this ligament is covered inwardly by the articular synovial membrane.

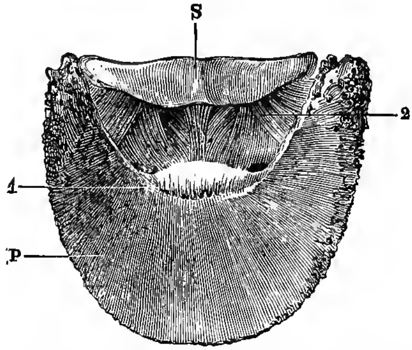
Fig. 135.



METATARSO PHALANGEAL AND INTER-PHALANGEAL ARTICULATIONS OF THE HORSE.

These are almost the same as in the anterior limb. 1, Superficial layer of the external lateral ligament of the metatarso-phalangeal articulation; 2, sesamoid branch of the deep layer; 3, phalangeal branch of the same; 4, superior branch of the glenoidal fibro-cartilage; 5, middle branch of ditto; 6, inferior branch of ditto; 7, lateral ligament of the first interphalangeal articulation; 8, posterior lateral ligament of the pedal articulation; 9, anterior lateral ligament of ditto.

Fig. 136.



ARTICULATION OF THE FOOT (INFERIOR FACE).

P, Inferior face of the third phalanx. S, Inferior face of the navicular bone. 1, Semilunar crest; 2, interosseous ligament.

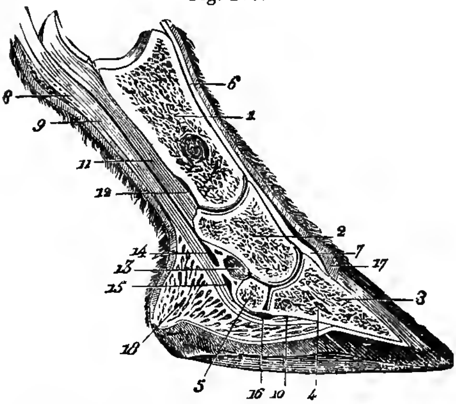
Synovial membrane.—This descends below the facets which unite the navicular to the pedal bone. It offers, posteriorly, a vast *cul-de-sac* which reaches the posterior face of the second phalanx, and lies against the two sesamoidean bursæ (Fig. 137, 13). It also forms another much smaller, by being prolonged between the two lateral ligaments of the same side. This is very often distended, and it is liable to be opened in the operation for diseased lateral cartilages.

Movements.—The same as those of the first interphalangeal articulation.

In the **Sheep** are found: 1. An interosseous ligament to unite the navicular bone to the third phalanx. 2. Two anterior lateral ligaments commencing, as already stated, at the first phalanx. 3. Two lateral posterior ligaments, passing to the posterior face of the second phalanx and the navicular bone (the internal is yellow and elastic). 4. A single, anterior, elastic ligament, attached above to the superior extremity of the second phalanx, and fixed below into the third, between the insertion of the common extensor of the digits and that of the internal anterior lateral ligament; an inferior interdigital ligament, situated between the ungueal phalanges, whose separation from each other it limits. This ligament is composed of parallel fibres, which extend transversely from the one navicular bone to the other, and is covered on its inferior face by the skin of the interdigital space. Its upper face is in contact with an adipose cushion.

In the **Ox**, the external anterior lateral ligament, wide and expanding, is almost entirely covered by the long branch of the proper extensor of the digit, to which it is intimately adherent. The interdigital ligament has a much more complicated character than that of the Sheep. It is formed of fibres intercrossed on the median line, and divided at its extremities into two fasciculi: a superior passes over the perforans tendon, to which it serves as a restraining band, and is fixed to the outside of the inferior extremity of the first phalanx, after contracting very close adhesions with a strong fibrous web which descends from the posterior metacarpal region, and which will be more fully noticed when describing the muscles; an inferior, shorter than the preceding, attached to the internal extremity ef the navicular bone and the internal face of the third phalanx, becoming confounded with the perforans tendon, the plantar cushion, and the dermis of the keratogenous membrane.

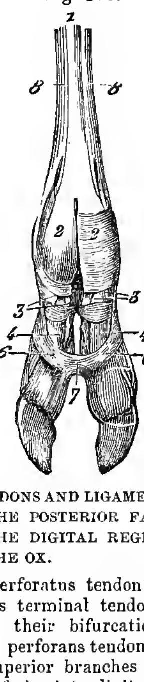
Fig. 137.



LONGITUDINAL AND VERTICAL SECTION OF THE DIGITAL REGION IN THE HORSE, SHOWING THE ARRANGEMENT OF THE ARTICULAR AND TENDINOUS SYNOVIAL APPARATUS.

1, First phalanx; 2, second phalanx; 3, third phalanx; 4, semilunar sinus of ditto; 5, navicular bone; 6, tendon of the anterior extensor of the phalanges; 7, its insertion into third phalanx; 8, tendon of the perforatus; 9, ditto perforans; 10, its insertion into the third phalanx; 11, inferior sesamoid ligaments; 12, posterior *cul-de-sac* of the first synovial interphalangeal capsule; 13, ditto of second; 14, inferior *cul-de-sac* of the sesamoid bursa; 15, superior ditto of navicular bursa; 16, inferior ditto of same; 17, section of the coronary cushion; 18, ditto of plantar cushion.

Fig. 138.



TENDONS AND LIGAMENTS OF THE POSTERIOR FACE OF THE DIGITAL REGION OF THE OX.

1, Perforatus tendon; 2, 2, its terminal tendons; 3, 3, their bifurcation; 4, 4, perforans tendon; 6, 6, superior branches of the inferior interdigital ligament attached to the first phalanx; 7, inferior interdigital ligament; 8, 8, suspensory ligament of the fetlock.

In the **Pig**, for the maintenance of the second interphalangeal articulation, there are: 1. Two lateral ligaments, carried from the lateral faces of the second phalanx to the external and internal faces of the third. 2. A third ligament, exactly resembling one of the posterior lateral ligaments of the pedal articulation of the Horse; this ligament descends from the inferior extremity of the first phalanx to the internal extremity of the navicular bone. Its analogue of the inner side appears to be altogether absent; but in the large digits there is an anterior yellow elastic ligament like that of Ruminants.

In the **Dog**, the two last phalanges are united by two lateral ligaments, very simply arranged. A third ligament, formed of elastic tissue, divided into two lateral portions, and situated in front of the articulation, plays the part of a spring, which mechanically produces the retraction of the claw when the flexor muscles cease to contract. In the **Cat**, this yellow ligament is very strong; and this animal also exhibits a very striking obliquity of the articular pulleys by which the two phalanges correspond: an arrangement that permits the claw to be lodged between two digits when they are raised, and thus favour its retraction.

The second interphalangeal articulation of the **Dog** and **Cat** is also distinguished by another essential arrangement. The articular surface of the third phalanx is completed by a glenoid fibro-cartilage analogous to that of the first articulation, but much thicker. This fibro-cartilage (see Muscles of the Hand) is fixed into the posterior projection of the third phalanx, and serves, by its inferior face, as a pulley for the perforans tendon and, with the projection just named, plays the part of the navicular bone in other animals.

The interphalangeal articulations of **Man** are formed on the same plan as the metacarpo-phalangeal articulations. They are consolidated by a glenoid and lateral ligaments, and possess only the two movements of *flexion* and *extension*.

Article V.—Articulations of the Posterior Limbs.

1. Articulations of the Pelvis.

(*Preparation.*—These ligaments are all exposed to view by carefully removing the soft parts connected with the sacrum and coxæ.)

A. Sacro-iliac Articulation (Figs. 139, 140).—This is a pair articulation which establishes the union of the posterior limb with the spine, and is formed by the sacrum and coxa. It belongs to the arthrodial class.

Articular surfaces.—On the sacrum, the irregular diarthrodial facet named the "auricular," cut on the sides and near the base of the bone. For the coxa, the analogous facet on the internal face of the ilium.

Mode of union.—By four ligaments, which, after the example of Rigot, we will name *sacro-iliac*, *superior ilio-sacral*, *inferior ilio-sacral*, and the *sacro-sciatic*. The first is situated immediately around the articular surfaces, and the others are only in mediate relations with them.

a. Sacro-iliac ligament (Fig. 140, 1).—This is composed of thick fibrous fasciculi, which envelop the whole articulation in being firmly attached by their extremities, to the imprints around the diarthrodial facets. The inferior moiety of this ligament is covered by the iliacus muscle. Its posterior half[1] is much stronger, is hidden by the ilium, and gives attachment to the longissimus dorsi muscle.

b. Superior ilio-sacral ligament (Fig. 139, 13).—A thick and short funicle, which, rising from the internal angle of the ilium, is carried backwards to be fixed to the sacral spine, where its fibres are confounded with those of the super-spinous dorso-lumbar ligament.

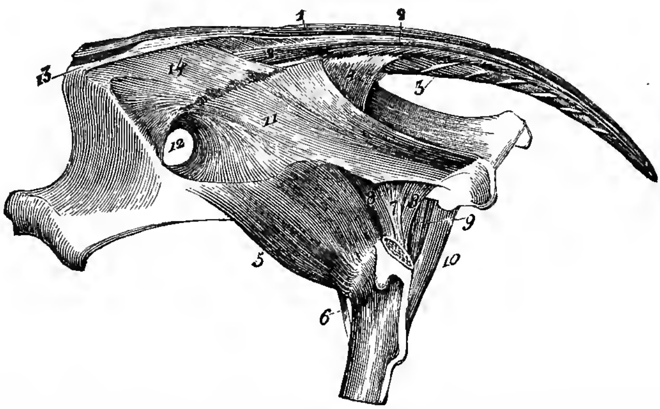
c. Inferior ilio-sacral ligament (139, 14).—This is very resisting, triangular, membranous band, formed of parallel fibres passing obliquely downwards and backwards. It is attached, by its anterior margin, to the upper half of the sciatic border and the internal angle of the ilium, in becoming confounded with the preceding ligament. Its inferior margin is inserted into the rugged lip which borders the sacrum laterally. Its posterior border is united to the aponeurosis covering the coccygeal muscles, and its external face is in contact with the principal gluteal and the long vastus muscles; while the internal lies against the lateral sacro-coccygeal muscle.

d. Sacro-sciatic or *ischiatic ligament* (Fig. 140, 2).—This is a vast membranous expansion situated on the side of the pelvis, between the sacrum and the coxa. It serves more as a means for enclosing this portion of the pelvic cavity, than to assure the solidity of the sacro-iliac articulation. Its form is irregularly quadri-

[1] It represents the *interosseous sacro-iliac ligament* of Man. The inferior half corresponds to the *anterior sacro-iliac ligament*.

lateral, and permits its circumference to be divided into four borders : a superior, attached to the rugged lateral ridge of the sacrum ; an inferior, fixed to the supracotyloid ridge, as well as the ischial tuberosity, and forming by the portion comprised between these two insertions, with the small ischiatic notch, the opening by which the internal obturator and pyramidalis muscles leave the pelvis ; an anterior, imperfectly limited, along with the great sciatic notch, circumscribes the opening through which the gluteal vessels and nerves, and the sciatic nerves pass ; a posterior, doubled in the form of two layers which embrace the semimembranosus muscle, and is confounded superiorly with the aponeurosis enveloping the coccygeal muscles. The external face of this ligament is traversed by the sciatic nerves, and is covered by the long vastus and the semitendinosus muscles, which derive numerous insertions from it. Its internal face is covered, in front,

Fig. 139.



SACRO-ILIAC AND COXO-FEMORAL ARTICULATIONS, WITH THEIR SURROUNDIHG MUSCLES.
11, Sacro-sciatic ligament; 12, great sciatic notch; 13, superior ilio-sacral ligament; 14, inferior ilio-sacral ligament.

by the peritoneum, and, posteriorly, is in contact with the ischio-coccygeal and ischio-anal muscles, to which it gives attachment.

Synovial membrane.—This lines the sacro-iliac ligament, but only furnishes a small quantity of synovia.

Movements.—The two sacro-iliac articulations, being the centres towards which all the propulsive efforts communicated to the trunk by the posterior limbs converge, do not offer much mobility, as that would oppose the integral transmission of the propulsion. So that they permit only a very restricted gliding of the articular surfaces ; while the union of the sacrum and coxa by diarthrosis, appears to be exclusively designed to prevent the fractures to which these bones would be incessantly exposed, if they were fixed together in a more intimate manner.

B. Articulation of the two Coxæ, or Ischio-pubic Symphysis.—The two coxæ are united to each other throughout the whole extent of the inner border of the pubis and the ischial bones. In youth, this is a veritable amphiarthrosis, fixed by an interosseous cartilage and bundles of peripheral fibres.

The cartilage is solidly fixed to the small rugged eminences which cover the adjacent articular surfaces, and becomes ossified, like the sutural cartilages, as the animal advances in age. In adult Solipeds the coxæ are constantly fused to each other.

The peripheral fibrous fasciculi extend transversely from one bone to the other, above and below the symphysis; those on the inferior face are incomparably stronger and more abundant than the others.

The movements of this articulation are most restricted, and depend solely upon the elasticity of the interosseous cartilage. They cease after its ossification.

The fusion of the two coxæ proceeds very slowly in the *female* of the **Cat, Dog, Pig, Ox, Sheep,** and **Goat** species.

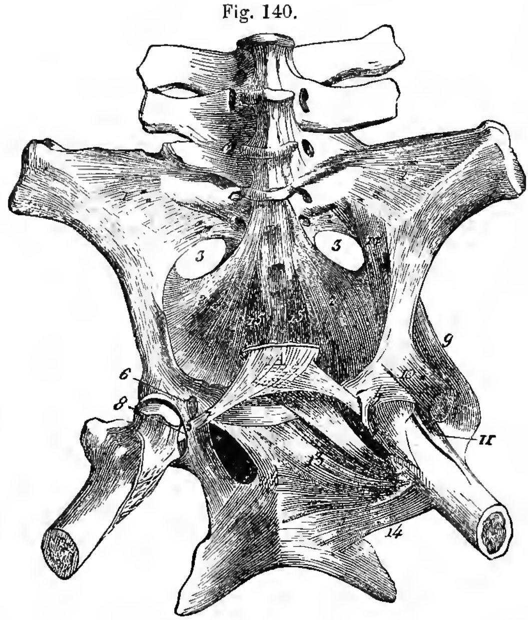
2. Coxo-femoral Articulation (Fig. 140).

(*Preparation.*—Remove the muscles surrounding the articulation. To view the interior, divide the capsular ligament by a circular incision.)

This is an enarthrosis, formed by the reception of the head of the femur into the cotyloid cavity of the coxa.

Articular surfaces.—As already shown, the cotyloid cavity represents the segment of a hollow sphere, deeply notched on the inner side, and provided at the bottom with a wide depression, the internal moiety of which is destined for the insertion of one of the interosseous ligaments, while the external half plays the part of a synovial fossa. This depression is not covered by cartilage, and communicates by the internal notch with the inferior furrow on the pubis. The lip of the cotyloid cavity is covered by a complementary fibro-cartilage—the *cotyloid ligament.* This fibro-cartilage is not interrupted at the notch just mentioned, but passes over it, forming a remarkable band (Fig. 140, 5) that converts it into a foramen, through which pass the pubio- or ilio-femoral ligament and the vessels of the articulation. Fixed by its adherent border to the margin of the cotyloid cavity, this ligament is lined by synovial membrane on its faces and free border. It is thickest in front and within.

Fig. 140.



SACRO-ILIAC AND COXO-FEMORAL ARTICULATIONS, WITH THE SMALL DEEP MUSCLES SURROUNDING THE LATTER (INFERIOR SURFACE).

1, Sacro-iliac ligament; 2, sacro-sciatic ligament; 3, great sciatic notch; 4, anterior portion of the capsular ligament of the coxo-femoral articulation; 5, internal band of the cotyloid ligament; 6, coxo-femoral ligament; 7, pubio-femoral ligament; 8, its insertion into the femur.

With regard to the head of the femur, it will be remembered that it is exactly moulded to the cavity, and, like it, is excavated by a rugged fossa which is entirely occupied by the insertion of the interarticular ligaments.

Mode of union.—This joint is maintained by a peripheral capsule, and by an interarticular band constituting the coxo-femoral ligament.

a. Capsular ligament (Fig. 140, 4).—This is a membranous sac, like that of the scapulo-humeral articulation, embracing the head of the femur by its inferior opening, and attached by its opposite border to the margin of the cotyloid cavity and its surrounding fibro-cartilage. This ligament is composed of intercrossed fibres, and is strengthened in front by an oblique fasciculus which descends to the body of the femur, along with the crureus muscle, near which it is fixed. Its internal face is covered by the articular synovial membrane, and its external face is in contact, through the medium of adipose cushions, with : in front, the crureus and the rectus femoris ; behind, the gemini, the internal obturator, and the pyramidalis muscles ; outwards and upwards, the small gluteal muscle ; within and below, the external obturator.

b. Coxo-femoral ligament (*ligamentum teres*, Fig. 140, 6).—A thick and short funicle of a triangular shape, deeply situated between the two bony surfaces, which it cannot, notwithstanding its shortness, maintain exactly in contact without the other muscular or ligamentous structures enveloping the articulation. In Solipeds, it is divided into two portions—a *cotyloid* and a *pubic*. The cotyloid portion is short and entirely concealed in the interior of the articulation (Fig. 140, 6). Its upper insertion occupies the internal moiety of the bottom of the cotyloid cavity ; and its inferior extremity is fixed into the rough fossa in the head of the femur. It is enveloped by the synovial membrane.

The *pubic* portion (Fig. 140, 7, 8) arises, like the preceding, from the fossette in the head of the femur, and, passing upwards and outwards, enters the internal notch of the cotyloid cavity, is inflected downwards on the fibrous band which converts that notch into a foramen, and is at last lodged in the inferior furrow on the pubis, becoming confounded with the prepubic tendon of the abdominal muscles, at the anterior border of the pubis. Longer and stronger than the cotyloid portion, this fasciculus is included, in its pubic part, between the two branches of the pectineus ; its interarticular part is covered by synovial membrane.

Synovial membrane.—This membrane is very extensive ; it lines the internal face of the capsular and cotyloid ligaments, and is reflected on the interarticular ligaments, to form around them a serous vaginal covering. It is even prolonged into the synovial fossa occupying the centre of the cotyloid cavity.

Movements.—The coxo-femoral articulation is one of the joints which are endowed with the most varied and extensive movements. It permits the *flexion*, *extension*, *abduction*, *adduction*, *circumduction*, and *rotation* of the thigh on the pelvis. The mechanism of these movements is so simple, that they need no particular consideration.

The domesticated animals other than Solipeds, are distinguished by the complete absence of the pubio-femoral ligament ; so that in them the movements of abduction, which are limited in Solipeds by the tension of this ligament, are much more extensive ; and it is the absence of the ligament in question which explains the facility with which the larger Ruminants are enabled to strike sideways—a movement known as a "cow's kick."

In Man, the head of the femur is more detached than in the domesticated animals, and the cotyloid cavity, encircled by the cotyloid ligament, is deeper. The femur is united to the coxa : 1. By a capsular ligament. 2. By a triangular ligament, fixed above, to the cotyloid ligament at the notch, and below, into the depression in the head of the femur. Also, as the brothers Weber have shown, the atmospheric pressure is a powerful adjunct to these means of union.

The coxo-femoral articulation of Man permits more extensive movements than that of animals, and especially abduction and adduction, which can be carried to 90 degrees.

3. Femoro-tibial Articulation (Fig. 141).[1]

Preparation.—Remove the soft parts surrounding the articulation, taking care not to wound the synovial membrane. To expose the crucial ligaments, make an antero-posterior vertical section of the femur in such a way as to separate the condyles.

This is the most complicated joint in the body, and is formed by the union of the femur with two of the thigh-bones—the tibia and patella. It represents an imperfect hinge-joint.

Articular surfaces.—To form this articulation, the femur opposes its two condyles to the wide, convex, and undulated facets on the superior face of the lateral tuberosities of the tibia, and its articular pulley to the posterior face of the patella.

The *femoral faces* have already been described in detail (p. 137); but it may be repeated that the two condyles, placed side by side, are elongated in an antero-posterior direction, and are separated by a non-articular notch called the inter-condyloid; also, that the femoral trochlea, situated in front of these two condyles, appears to continue the preceding notch, and that its internal border is much more elevated than the external—an arrangement which explains why it is so difficult, if not impossible, for the patella to be dislocated inwards.

The *tibial facets* ascend on each side to the lateral faces of the tibial spine. They are separated from one another by the antero-posterior groove cut on the summit of that bone, and by the fossæ of insertion situated at its base before and behind. The external facet, wider than the internal, is devoted in part to the gliding of the originating tendon of the popliteal muscle.

The *patellar surface*, moulded on the femoral pulley, fits it in an imperfect manner. It is bordered, outwardly, by a small fibro-cartilaginous ring, which is united to the fibrous capsule of the femoro-patellar articulation (Fig. 141, 1). Inwardly, it is completed by the insertion of the internal patellar ligament, to be noticed immediately.

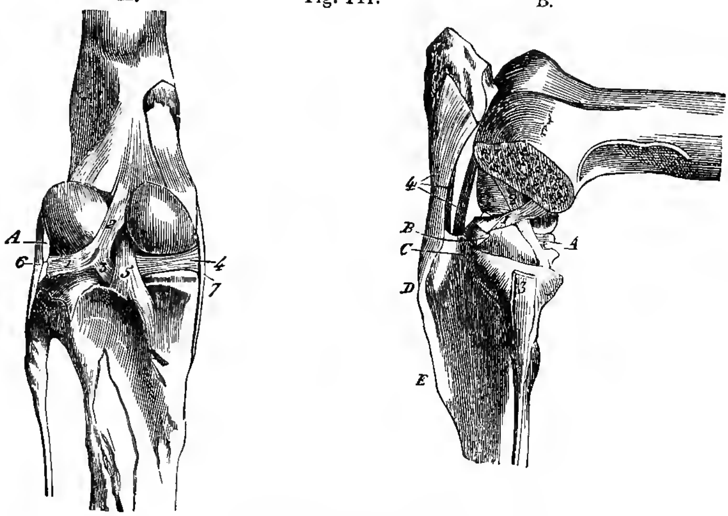
Interarticular meniscii (*semilunar fibro-cartilages*) (Figs. 141, A 1, 2, 3, 4; and 142, 5, 6, 7, 8).—By this designation are known the two fibro-cartilages interposed between the condyles of the femur and the tibial facets, to assure their coaptation. They are crescent-shaped bodies, and present: an internal, concave, thin, and sharp border, embracing the tibial spine; an external, thick, and convex border; a superior face, excavated and moulded to one of the condyles; an inferior face, nearly plane, gliding on the tibia; and two extremities terminated by ligaments, and fixed to the bones in apposition. The articular surfaces are not entirely separated throughout their extent by these complementary meniscii, for the tibial spine rubs directly against the inner sides of the femoral condyles. The *internal semilunar fibro-cartilage*, the widest and thickest, is inserted by its anterior extremity into one of the excavations situated in front of the spine; its posterior

[1] By this name is understood the joint uniting the femur to the tibia, and that which articulates it with the patella. Following the example of anthropotomists, it has not been deemed necessary to describe a femoro-patellar articulation distinct from the femoro-tibial, properly so called. This innovation appears to be justified by the community of the principal articular bands which bind these two joints, and by the reciprocal dependence of their movements.

extremity is attached in the fossa behind that eminence. The *external semilunar fibro-cartilage* is fixed, in front, near the anterior insertion of the opposite fibro-cartilage ; its posterior extremity gives origin to two slips or cords, one superior, the other inferior. The first, the strongest and longest, terminates in the fossa near the posterior extremity of the intercondyloid notch. The second, thin and flat, is inserted on the posterior outline of the external tibial facet. The external border of this meniscus is separated from the external lateral ligament by the tendon of the popliteus muscle, and acts, with regard to this tendon, as a pulley.

Mode of union.—The bands which bind this complicated articulation are very

A. Fig. 141. B.



FEMORO-TIBIAL ARTICULATION.

A.—Posterior face: the posterior ligament has been removed. 1, External meniscus; 2, fibrous fasciculi fixing it to the femur; 3, fibrous fascia which attaches it to the posterior contour of the tibial surface; 4, internal meniscus; 5, tibial insertion of the posterior crucial. ligament; 6, external lateral ligament; 7, internal lateral ligament.

B.—External face: the external condyle of the femur and the meniscus have been removed to show the crucial ligaments. 1, Anterior crucial ligament; 2, posterior ditto; 3, fibular insertion of the external lateral ligament; 4, anterior patellar ligaments. A, Internal meniscus; B, anterior insertion of the external meniscus; C, passage for the tendinous cord common to the flexor of the metatarsus and the anterior extensor of the phalanges; D, anterior and superior tuberosity of the tibia; E, tibial crest.

numerous. They will be successively described as: 1. Those which attach the patella to the tibia. 2. Those which unite the femur with the tibia.

A. *Ligaments attaching the patella to the tibia.*—The patella is bound to the tibia by three funicular ligaments, designated by the generic epithet of "patellar." They are situated in front of the articulation, and transmit to the leg the action of the muscles which are attached to the patella. They are distinguished according to their position, as external, internal, and middle (Fig. 142, 2, 3, 4).

a. The *external patellar ligament*, the largest and most powerful, is a flattened band, attached, by its lower extremity, to the culminating point of the anterior tuberosity of the tibia. Its upper extremity is fixed to the anterior face of the patella, and is confounded with the patellar insertion of the superficial gluteus. It is joined to the internal ligament by a very resisting aponeurotic extension, a dependency of the *fascia lata*.

b. The *internal patellar ligament* also forms a flattened band, longer, but not so wide or thick as the preceding. Its inferior extremity is attached to the inner side of the anterior tuberosity of the tibia. Its superior extremity becomes much thickened and fibro-cartilaginous, and is inserted into a prominence inside the patella. This fibro-cartilaginous portion (Fig. 142, 3) of the ligament glides on the internal border of the femoral trochlea, and may justly be considered as a complementary apparatus of the patellar surface. The ligament, joined to the preceding by the fibrous fascia already mentioned, is confounded, inwardly, with the aponeurosis of the adductor muscles of the leg.

c. The *middle patellar ligament* is a round cord, situated, as its name indicates, between the other two, concealed beneath the aponeurosis which unites these, and in the middle of the adipose tissue protecting the synovial capsules in front. It leaves the anterior face of the patella, and descends vertically to the tibia, to be lodged in the fossa in the middle of the anterior tuberosity, where a small synovial bursa facilitates its movements. Its inferior extremity is inserted into the most declivitous part of this excavation.

B. *Ligaments which attach the leg and thigh bones.*—These are six in number: 1. A femoro-patellar capsule maintaining the patella against the femoral trochlea. 2. Five femoro-tibial ligaments, as follows: two lateral, two external and internal; a posterior; and two interarticular, distinguished with reference to their inferior insertion into anterior and posterior.

1. The *femoro-patellar capsule* is a membranous expansion which covers, above and laterally, the superior synovial membrane. This capsule is attached by its borders around the femoral trochlea and the periphery of the patellar surface. It is extremely thin in its superior part; but laterally it is thicker, and constitutes two wide fibrous fasciculi which bind the patella to the eccentric sides of the two condyles, and is described in several works as two special ligaments. Its external face is covered by the insertion of the superficial gluteus and the triceps cruralis.

2. *Femoro-tibial ligaments.*—*a.* The *lateral ligaments* are two ribbon-shaped cords situated at the extremities of the transversal axis of the articulation, more behind than before; they are relaxed during flexion, and very tense in extension.

The *external*, the shortest and strongest, proceeds from one of the hollow facets on the external condyle of the femur, and is inserted into the head of the fibula by its inferior extremity, after gliding over the external tuberosity of the tibia by means of a special synovial bursa. It is covered by the crural or tibial aponeurosis, and covers the tendon of the popliteus, from which it is sometimes separated by a vesicular synovial membrane.

The *internal* is attached, superiorly, to the eminence of insertion that surmounts the eccentric face of the internal condyle, and descends vertically to the tibia, gliding over the margin of its articular surface by means of a small facet covered with cartilage, and a *cul-de-sac* prolongation of the internal synovial membrane. It is fixed by its inferior extremity to the imprints which cover the internal tibial tuberosity.

Its fibres are disposed in two layers, which slightly intercross in X fashion; those passing downwards and forwards adhere to the border of the internal meniscus. Covered by the aponeurosis of the adductor muscles of the leg, this ligament adheres by its deep face to the internal meniscus.

b. The *posterior ligament* belongs to the class of membranous or capsular ligaments. It is formed of two aponeurotic layers separated superiorly, but confounded inferiorly. The superficial layer is composed of strong, fibrous, intercrossed fasciculi, perforated with vascular openings. It is fixed, above, to the posterior face of the femur, below the external gastrocnemius muscle. The deep lamina envelops, like a cap, the femoral condyles. After becoming united, these two laminæ are attached to the posterior face of the tibia, close to the superior articular face of that bone. Its external face is in contact with the popliteal vessels, and the gastrocnemius muscle. Its internal face is covered throughout nearly the whole of its extent by the lateral synovial membranes, embraces the condyles of the femur, and adheres to the posterior crucial ligament, as well as to the interarticular meniscii.

c. The *interosseous ligaments* are two funicular bands lodged in the intercondyloid notch. They are more commonly designated *crucial ligaments*, because they cross each other at their middle part, like the letter X (Fig. 141).

The *anterior*, oblique downwards and forwards, is attached by its superior extremity to the bottom of the intercondyloid notch, and inwardly to the external condyle. Its inferior extremity is fixed in the groove on the summit of the tibial spine. The fibres entering into its formation are not parallel, but slightly twisted in a spiral manner.

The *posterior*, longer than the preceding, and oblique in the opposite direction, is inserted, inferiorly, into the little eminence behind the internal tibial facet; whence it goes to the bottom of the intercondyloid notch, to be attached by its superior extremity within the internal condyle.

Synovial membranes.—For this articulation there are three synovial membranes: a superior and two lateral. The first, very large and strengthened by the femoro-patellar capsule, facilitates the gliding of the patella on the femoral pulley; it is prolonged in a *cul-de-sac* below the insertion of the crural triceps. The other two, which lubricate the articular surfaces of the proper femoro-tibial joint, include the crucial ligaments between them, and cover the posterior ligament, the lateral ligaments, and the fibrous fasciculi for the attachment of the meniscii. The external lines, in addition, the tendon of the popliteus muscle, and furnishes a vast *cul-de-sac* which descends in the anterior groove of the tibia, to envelop the tendon common to the anterior extensor of the phalanges and the flexor of the metatarsus. These two femoro-tibial synovial membranes lie against that of the femoro-patellar articulation, in front of the condyles and the notch which separates them, and if not always, at least not unfrequently, they communicate with it. The three are separated from the ligaments of the patella by a considerable mass of adipose tissue, which is prolonged into the inter-condyloid notch, at the bottom of which it appears to be fixed.

The synovial cavities sometimes communicate with each other, but, according to Lesbre, this is rare.

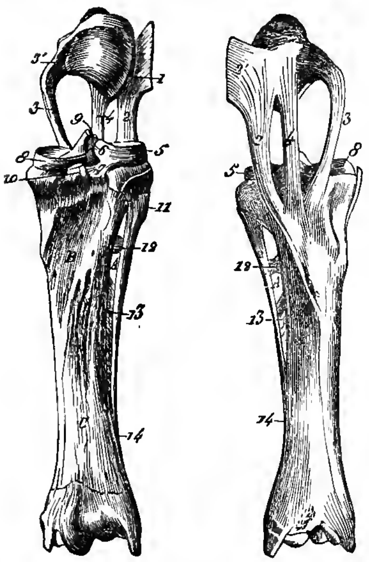
Movements.—This imperfect hinge-joint can execute the two principal and opposite movements of *flexion* and *extension*, and a somewhat limited accessory movement of *rotation*. The mechanism of these movements being simple enough to be readily understood without any preliminary explanation, they will not be detailed here; but some remarks will be made with regard to the displacement the fibro-cartilages undergo, when the articulation is in motion.

During *flexion* and *extension*, these bodies, fixed on the tibial facets, which they transform into glenoid cavities, move with them on the condyles of the femur, from before to behind, or behind to before, according to the movement executed. But at the same time they also glide in an inverse direction, and to a very appreciable degree, on the superior extremity of the tibia. Therefore, during flexion, they pass from behind forward on this extremity, and are drawn backwards during extension.

In *rotation*—which may take place from within to without, or from without to within—the movement is produced not only by the pivoting of the condyles in their glenoid cavities, but also by a sensible displacement of the menisci on the tibial surfaces.

Fig. 142.

No. 1. No. 2.



LIGAMENTS ATTACHING THE THREE BONES OF THE LEG.

No. 1. Posterior face. No. 2. Anterior face. 1, Complementary fibro-cartilaginous pad of the patellar surface; 2, external patellar ligament; 2′, insertion of the superficial gluteal into this ligament; 3, internal patellar ligament; 3′, its upper insertion transformed into a complementary apparatus of the patellar surface; 4, middle patellar ligament; 5, external meniscus of the tibia; 6, its branch of insertion into the femur cut off at its origin; 7, its posterior tibial insertion; 8, external meniscus; 9, insertion of the anterior crucial ligament into the fossa of the tibial spine; 10, tibial insertion of the posterior crucial ligament; 11, inferior insertion of the external femoro-tibial ligament; 12, 13, 14, tibio-fibular ligaments. A, Tibial arch; B, surface of insertion of the popliteus muscle; C, surface of insertion for the perforans muscle.

In the **Dog** and **Cat**, the menisci are joined together, near their anterior insertion, by a transverse fibrous band. There is only one patellar ligament, and the posterior ligament shows in its substance, two small sesamoid bones against which the condyles of the femur play inwardly, and which give attachment, outwardly, to the originating branches of the gastrocnemius muscle. There is no femoro-patellar capsule, and only one synovial membrane for the whole articulation.

In the **Pig** and **Sheep**, there is also only one ligament and one synovial capsule.

4. Tibio-fibular Articulation.

This articulation represents a small planiform diathrosis, the movements of which are very limited and obscure. It is formed by the union of the irregular diathrodial facet which occupies the internal face of the head of the fibula, with the analogous facet on the external superior tuberosity of the tibia. Short and strong interosseous or peripheral fibres envelop these facets on every side, and maintain them firmly in contact.

The fibula is also attached to the tibia: "1. Above, by two small ligamentous fasciculi crossed like the letter X, which form the superior part of the great arch through which pass the anterior tibial artery and vein (Fig. 142, 12). 2. In the middle, by a kind of aponeurotic membrane, the width of which diminishes from above to below, like that of the space it fills (Fig. 142, 13). 3. Below, by a ligamentous cord (Fig. 142, 14) which prolongs the fibula to the external tuberosity of the inferior extremity of the tibia, where this cord bifurcates, and is united to the two external lateral ligaments of the tibio-tarsal articulation" (Rigot).

In the **Ox**, **Sheep**, and **Goat**, the fibula being replaced by a ligament, there is no proper tibio-fibular articulation.

In the **Dog** and **Cat**, the two principal bones of the leg are united at their extremities and middle part:

1. At their superior extremity, by means of a small arthrodial articulation, analogous to that of the Horse, and, like it, provided with a particular synovial bursa;

2. At their inferior extremity, by means of a second arthrodial articulation, whose action is facilitated by a prolongation of the tibio-tarsal synovial membrane;

3. By their middle part, through the interposition, between the two bones, of an interosseous ligament, which is wide and membranous in its upper two-thirds, and formed of extremely short and strong fibres at its lower third.

5. Articulations of the Tarsus or Hock (Figs. 141, 144).

Preparation.—Commence by cutting off the tendons, and so exposing the lateral ligaments of the tibio-tarsal diathrosis. Then the procedure should be as for the carpus—dissect successively the ligaments proper to each row, those uniting the two rows, and those binding the lower row to the metatarsus.

These comprise: 1. The tibio-tarsal articulation. 2. The articulation of the first row of bones—the astragalus and calcaneum or calcis. 3. Those which unite the bones of the lower row. 4. The articulation of the two rows with each other. 5. The tarso-metatarsal articulation. The first is a perfect ginglymoid, and the only joint really movable; all the others are arthrodial, and their action is so restricted that they appear to be condemned to almost absolute immobility. This intimate union of the tarsal and metatarsal bones, is evidently chiefly intended to guarantee precision in the movements of the tibio-tarsal articulation.

Tibio-tarsal Articulation.—Two bones alone concur in the formation of this angular ginglymoid joint: these are the tibia and astragalus.

Articular surfaces.—For the tibia: 1. The two deep grooves, oblique forwards and outwards, channeled in the inferior extremity of the bone. 2. The salient tenon which separates these grooves, and on which there is often a small synovial fossette. For the astragalus, the pulley occupying its anterior face (see p. 145).

Mode of union.—Seven ligaments bind these articulations: two external lateral, three internal lateral, an anterior, and a posterior.

a. External lateral ligaments.—These are distinguished, according to their relative position, into superficial and deep.

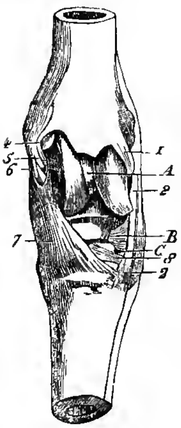
The *external superficial ligament* (Figs. 143, 2; 144, 2) is a thick funicular cord, flattened in its inferior half. It commences above on the external tuberosity of the tibia, behind the groove which divides this tuberosity into two parts; from thence it descends almost vertically, fixing itself successively to the astragalus, calcaneum, cuboides, middle metatarsal bone, and the external rudimentary metatarsal bone. Passing in front with, and partly covered by, the lateral extensor of the phalanges, to which it supplies a retaining band (Fig. 143, 2), this ligament is confounded behind, and near its inferior extremity, with the calcaneo-metatarsal ligament. It covers the external and deep ligament, the short band which constitutes the external calcaneo-astragaloid ligament, the insertion of one of the branches of the flexor of the metatarsus, and the small cuboido-cunean (cuneiform) ligament.

The *external deep ligament* (Figs. 143, 1; 144, 1), much shorter than the preceding, is attached, superiorly, to the anterior part of the external tuberosity of the tibia, and is directed obliquely backwards and downwards, to be fixed by two fasciculi at the external side of the astragalus and calcis. This ligament, covered by the preceding, which crosses it like an X, is lined on its inner face by a synovial membrane of the articulation.

b. Internal lateral ligaments.—These are also three funicular bands superposed on one another, and are consequently designated as superficial, middle, and deep.

The *internal superficial ligament* (Fig. 143, 6), the strongest and longest of the three, proceeds from the internal and inferior tuberosity of the tibia, diminishing as it descends on the inner side of the tarsus. It is fixed, in mixing with the astragalo-metatarsal ligament and with the posterior tarso-metatarsal ligamentous arrangement, to the tuberosity of the astragalus, the scaphoid, the two cuneiform, the superior extremity of the principal metatarsal, and that of the internal rudimentary metatarsal bones.

Fig. 143.



TARSAL ARTICULATIONS (FRONT VIEW).

1, External deep ligament of the tibio-tarsal articulation; 2, 2, external superficial ligament; 4, internal deep ligament; 5, internal middle ligament; 6, Internal superficial ligament; 7, astragalo-metatarsal ligament; 8, small cuboido-cunean ligament. A, Pulley of the astragalus; B, cuboidal insertion belonging to tne tendinous cord of the flexor of the metatarsus; C, vascular canal of the tarsus.

The *internal middle ligament* (Fig. 143, 5) is composed of two funicular cords, attached in common beneath the preceding ligament to the internal tibial tuberosity. These two fasciculi, exactly resembling those of the external deep ligament, are directed downward and backward, and terminate, one at the astragalus, the other at the calcis.

The *internal deep ligament* (Fig. 144, 4) is an extremely slender fasciculus, enveloped by the synovial membrane; it is often reduced to a thin shred, scarcely distinct from the serous covering surrounding it. It is attached, in one direction, to the tibia below the middle ligament; in the other, to the astragalus, and nearly at the same point as the superior fasciculus of the middle ligament.

c. Anterior ligament.—This is a membraniform band formed of intercrossed fibres, stronger outwards than inwards, attached by its upper border above and in front of the tibial surface, fixed by its inferior border to the astragalus, the scaphoid and great cuneiform bones, and the astragalo-metatarsal ligament; it is confounded at its sides with the two superficial lateral ligaments. Its internal face is lined by articular synovial membrane, while the external is covered by the flexor of the metatarsus, the anterior extensor of the phalanges, the anterior tibial artery, and several large anastomosing veins, from the junction of which arises the anterior tibial vein.

d. Posterior ligament.—This is the second membraniform or capsular band, which protects the articulation posteriorly. It presents, in its centre, a fibro-cartilaginous thickening, on which glides the perforans tendon. It is attached, above, to the tibia; below, to the astragalus and calcis; at its sides it is mixed with the two superficial lateral ligaments, and the astragalian fasciculus of the middle internal ligament. Its internal face is lined by articular synovial membrane; the external is covered and lubricated by the vaginal serous membrane, which facilitates the gliding of the perforans tendon in the tarsal sheath.

Synovial membrane.—This membrane is developed at the internal face of the two capsular ligaments, lines the greater part of the three internal ligaments, and also the external deep ligament. It communicates, in front and below, with the synovial membrane proper to the articulation of the two rows of tarsal bones. When it becomes the seat of dropsical effusion, it is always distended forwards and inwards, because it is only sustained at that place by the anterior capsular ligament. But the effusion may also elevate the posterior ligament, and produce hernia in the hollow of the hock, behind the lateral ligaments. It is not, therefore, absolutely correct to attribute all the synovial tumours in the hollow of the hock to dilatation of the tarsal tendinous sheath. (See the figure of the tendons and synovial capsules of the posterior limb, in the description of the perforans muscle.)

Movements.—Nothing can be less complicated than the mechanism of the tibio-tarsal articulation, this joint only permitting two opposite movements—those of *flexion* and *extension*—which are so simple and precise that we may dispense with a description of the manner in which they are executed. It may only be remarked that, in order to prevent contact between the leg and foot during flexion, the latter fraction of the limb deviates a little outwards, owing to the marked obliquity of the articular grooves.

Articulation of the Bones of the First Row, or Calcaneo-astragaloid Articulation.—This is a compound arthrodial joint, resulting from the coaptation of the three or four articular facets of the posterior face of the astragalus with the analogous facets of the calcis.

This joint is maintained by the lateral ligaments of the tibio-tarsal articulation, and by four *calcaneo-astragaloid ligaments*—a *superior*, *external*, *internal*, and the last *interosseous*.

The *superior calcaneo-astragaloid* ligament is formed of short parallel fibres thrown across from one bone to the other, and is situated towards the superior extremity of the pulley of the astragalus; it is lined superiorly by the synovial membrane of the tibio-tarsal articulation.

The *lateral* ligaments are two very thin fasciculi concealed by the ligaments which bind, laterally, the tibia to the tarsal bone.

The *interosseous* ligament is very strong, and occupies a great portion of the rugged excavation which separates the articular facets.

This articulation does not usually possess proper synovial capsules. Two prolongations of the synovial membrane of the two rows, in ascending between the calcis and astragalus, facilitate the gliding of the two inferior facets. An analogous prolongation of the tibio-tarsal synovial membrane is effected for the superior facets, and it is not rare to find this prolongation form a distinct capsule.

Movements nearly null.

Articulation of the Bones of the Second Row with each other.—These bones, four in number, are brought into contact in the following manner: The cuboides responds to the scaphoid by two facets—one anterior, the other posterior; it articulates with the great cuneiform by two similar facets, the posterior of which is not always present. The scaphoid is united to the two cuneiforms by the large convex facet occupying its entire lower face. The two cuneiforms are joined by means of a small articular surface.

The fibrous fasciculi which maintain the diarthrodial surfaces in contact are somewhat numerous. They are as follows:—

1. The astragalo-metatarsal ligament and tarso-metatarsal apparatus, which will be described hereafter; these two bands do not properly belong to the articulations of the second row of bones.

2. Two anterior ligaments, named *cuboido-scaphoid* and *cuboido-cunean* (Figs. 143, 8; 144, 5), which are carried from the cuboid to the scaphoid and to the

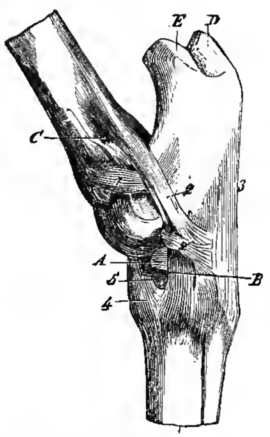
great cuneiform bone, one above, the other below the vascular channel formed between these three bones.

3. Two interosseous ligaments analogous to the preceding two, forming the superior and inferior walls of the aforesaid channel.

4. An interosseous *scaphoido-cunean* ligament, passing from the scaphoid to the two cuneiform bones.

5. An interosseous ligament, named the *intercunean*, is directed from one cuneiform bone to the other, and is confounded with the preceding ligament.

Fig. 144.



ARTICULATIONS OF THE TARSUS (LATERAL VIEW).

1, External deep ligament; 2, external superficial ligament; 2′, ring furnished by the latter ligament for the passage of the lateral extensor tendon of the phalanges; 3, calcaneo-metatarsal ligament; 4, astragalo-metatarsal ligament; 5, small cuboido-cunean ligament. A, Cuboidal insertion of the flexor muscle of the metatarsus; B, anterior orifice of the vascular conduit of the tarsus; C, groove on the external tuberosity of the tibia for the gliding of the lateral extensor of the phalanges; D, insertion of the gastrocnemius tendon of the leg into the os calcis; E, gliding surface for that tendon.

The disposition of the lubricating membranes varies with that of the articular facets. The following is what is most generally observed: A proper synovial membrane is specially destined for the facets by which the scaphoid and great cuneiform bones correspond; this synovial membrane belongs also to the two cuboido-scaphoid and posterior cuboido-cunean arthrodiæ. The anterior cuboido-scaphoid diarthrosis receives a prolongation from the synovial membrane of the two rows. The play of the anterior cuboido-cunean and intercunean facets is facilitated by two prolongations of the tarso-metatarsal synovial membrane.

Movements almost null.

ARTICULATION OF THE TWO ROWS WITH EACH OTHER.—This arthrodial joint is formed by the union of the calcis and the astragalus, on the one side, with the scaphoid and cuboid bones on the other. Its solidity is assured by six principal bands:

1. The two lateral superficial ligaments of the tibio-tarsal articulation.

2. The *calcaneo-metatarsal* ligament (Fig. 144, 3), a strong fibrous brace which unites the posterior border of the calcis to the cuboides, and to the head of the external rudimentary metatarsal bone. It is confounded, outwardly, with the external and superficial tibio-tarsal ligament; inwardly, with the posterior tarso-metatarsal band.

3. The *astragalo-metatarsal* ligament (Fig. 143, 7), a radiating fasciculus, the fibres of which leave the internal tuberosity of the astragalus, become mixed up with the internal and superficial tibio-tarsal ligaments in diverging downwards to the scaphoides, the great cuneiform bone, and the upper extremity of the principal metatarsal bone.

4. The *posterior tarso-metatarsal* ligament is a vast, very strong, and very complicated fibrous arrangement, which binds, posteriorly, all the tarsal bones, and also fixes them to the three portions of the metatarsus. This band, which is crossed by several tendons and by the artery and vein lodged in the cuboido-scaphoido-cunean canal, is continued below by the tarsal stay of the perforans tendon. It therefore closely resembles the posterior carpal ligament. Its posterior face is covered by the tendinous synovial membrane lining the tarsal sheath for

the passage of the perforans tendons. It is confounded, on its sides, with the calcaneo-metatarsal, and the internal and superficial tibio-tarsal ligaments.

5. An *interosseous ligament*, attached to the four bones composing this articulation.

It is provided with a particular synovial membrane which always communicates, in front, with the tibio-tarsal capsule. This membrane is prolonged, superiorly, between the calcis and astragalus, to lubrify two of the facets by which these bones come into contact ; and, in addition, it descends between the cuboid and scaphoid bones, to form a third prolongation for the anterior cuboido-scaphoid arthrodia.

Movements almost null.

Tarso-metatarsal Articulation.—This joint, formed by the meeting of the three tarsal bones—the cuboid and the two cuneiforms—with the three bones of the metatarsus, is fixed by the lateral superficial ligaments of the tibio-tarsal articulation, the calcaneo-metatarsal ligament, those which have been named the astragalo-metatarsal and tarso-metatarsal, and by a strong interosseous ligament which naturally forms three fasciculi.

The synovial membrane proper to this joint ascends into the small anterior cuboido-cunean arthrodia, and into that which unites the two cuneiform bones ; it descends to the intermetatarsal articulations.

Movements nearly null.

In all the domesticated animals except Solipeds, the tarsal articulations offer some differential peculiarities, the study of which is without interest, as it is without utility. It is only necessary to remark that the immobility of the tarsal joints, properly so called, is less absolute than in Solipeds, owing to the peculiar configuration of the articular surfaces of some of the bones composing them. Thus, in the **Ox, Sheep, Goat,** and **Pig,** the calcis is joined to the astragalus by a real trochlear articulation, and the latter bone is united to the scaphoid by a diarthrodial joint of the same kind—a mode of articulation much more favourable to motion than that of the planiform diarthrodial joint. In the **Dog** and **Cat,** the same result is obtained by the reception of the bead of the astragalus into the superior cavity of the scaphoid.

In **Ruminants** and the **Pig,** it is also observed that the tibio-tarsal articulation is formed by the tibia and fibula in the one direction, and by the astragalus and os calcis in the other.

Lemoigne, who has been again recently studying the mechanical arrangement of the Ox's hock, remarks that, if the mobility of all the tarsal articulations deprive the posterior limb of that animal of the rigidity necessary for speed, yet the nature of the astragalo-calcanean articulation gives it great power. In fact, the posterior trochlea of the astragalus acts as an eccentric on the calcis during movement, and gradually separates this bone in such a manner that the tendon of the gastrocnemius always remains nearly perpendicular on the lever arm—no matter to what degree the hock may be open or closed. But this mechanism may perhaps be disputed.

CHAPTER III.

THE ARTICULATIONS IN BIRDS.

The study of the articulations in birds will only arrest us for a few moments ; as it will be confined to some remarks on the intervertebral occipito-atloid and temporo-maxillary joints, the only ones exhibiting a special conformation worthy of attention.

Intervertebral articulations.—The great mobility of the neck of Birds is not only due to the fact of its length, relatively considered, but also to the peculiar manner in which the vertebræ of this portion of the spine are articulated. It will be remarked that these do not unite by their bodies in the form of a continuous series of amphiarthroses, as in the domesticated Mammals; but that, instead of these mixed articulations, there are real diarthroses, which may be included in the class created by Cruveilhier under the title of *articulation by reciprocal ball-and-socket*—each vertebra becoming connected with the adjacent vertebræ by means of facets, convex in one sense and concave in the sense perpendicular to the first. These facets are manifestly covered by cartilage of incrustation; and it appears that, instead of their being applied directly against the opposite facets, which present a precisely inverse conformation, they are separated by an extremely thin fibro-cartilaginous disc, which resembles the interosseous meniscus of the temporo-maxillary articulation in the Carnivora of the *Cat* species. Two loose synovial capsules, separated by this interarticular lamina, complete the framework of each articulation, and favour the play of the vertebræ on one another. This arrangement has only, so far as we are aware, been observed in the Swan, and that very imperfectly; but it probably belongs to the entire class of Birds, for until now we have met with it in all the individuals submitted to examination.

In its dorso-lumbar and sacral portion, the spine is a single piece, in consequence of the consolidation of the vertebræ, and does not show any proper articulations.

In the coccygeal region, the mobility of the spine reappears, but it is far from being so marked as in the cervical region; the vertebræ here are united by amphiarthrosis, and not by reciprocal ball-and-socket.

Occipito-atloid articulation.—It has been shown that there is only one more or less spheroidal condyle of the occipital bone, and a single cavity on the anterior margin of the spinal canal of the atlas. The occipito-atloid articulation is therefore a true enarthrosis, with varied and very extensive movements—a disposition which accounts for the facility with which Birds can pivot their heads on the superior extremity of the vertebral stalk.

Temporo-maxillary articulation.—The play of this articulation offers one peculiarity, in that it causes, during the separation of the mandibles, not only the depression of the inferior, but also the elevation of the superior mandible. The arrangement which permits this movement has been already alluded to (p. 189); but yet it is difficult to understand, because there is no active agent, no proper muscle to directly effect it. Nevertheless, the mechanism which executes it is most simple, and may be given in a few words. Thus, we know that the square bone, interposed between the temporal and maxillary bones, like the interarticular meniscus of Mammals, is united outwardly with the malar bone, and inwardly with the pterygoid. We know also that the latter rests, by means of a diarthrodial facet, on the body of the sphenoid, and that it abuts against the posterior extremity of the palatine bones (Fig. 109); while the first, the zygomaticus, is joined directly to the supermaxillary bone. The upper jaw, it is also known, is movable on the cranium, because of the flexibility of the cartilages or bony plates uniting these two portions of the head. It may then be added, that the square bone receives on its anterior process one or two small muscles, which are attached to the base of the cranium, and that these bones may be pushed, or rather drawn forward, by the contraction of these muscles. It is this projecting or pushing, transmitted to the upper mandible through the medium of the malar bone on the one side, and the pterygoid bone on the other, that produces the elevation of that mandible. Nothing is easier than to prove it; it is only necessary to take the head of a Bird, denude it of all its soft parts, and press with the fingers behind the two square bones, to imitate the action of the elevator muscles; we then see the internal extremity of the pterygoid bone glide on the facet of the sphenoid, and push before it the palatine bone, during which the zygomatic bone acts in the same manner on the maxillary; and in this way is produced, through the influence of this postero-anterior propulsion, the ascending movement we undertook to explain.

THIRD SECTION.

The Muscles.

After the study of the bony levers and their articulations, comes the description of the agents whose function it is to move them. These are the *muscles*—fibrous organs possessing the property of contracting under the influence of a stimulus.

They are distinguished as *striped* or *striated*, and *smooth* or *non-striated muscles*, according to the character of the anatomical element composing them.

The *striped muscles* differ from the *smooth*, in that, with the exception of the tissue of the heart, their contractile power is immediately placed under the influence of the will. They are more particularly concerned in the functions of relation, which cause them to be also named the *external muscles*, or *muscles of animal life*. These muscles are nearly all attached to the skeleton, and are the active agents in moving the bony framework; they will, therefore, be the only ones referred to in this place, in studying the locomotory apparatus.

The *unstriped muscles* are removed from the influence of the will, and belong to the organs of vegetative life. They are also designated *internal muscles*, *involuntary muscles*, or *muscles of organic life*.

But before entering upon the particular description of each muscle, we will allude to the general considerations relating to their history.

CHAPTER I.

GENERAL CONSIDERATIONS ON THE STRIPED MUSCLES.

THE STRIPED MUSCLES IN GENERAL.

In this first paragraph, we will survey, in a general manner, the volume, situation, form, direction, attachments, relations, and names of the muscles belonging to the locomotory apparatus.

A. Volume.—Nothing is more variable than the volume of the external muscles. What a difference there is, for example, between the small scapulo-humeralis muscle and the biceps femoris or longissimus dorsi, and what a number of intermediate sizes between these three points of comparison! There are consequently very great, great, medium, small, and very small muscles.

The weight of the total mass of these organs varies according to the species, age, sex, and state of health; but on taking a general average, it will be found that it represents nearly one-half the entire weight of the body.

B. Situation.—There is no need to insist upon the fact, that a knowledge of the situation of the muscles is one of the first objects to be acquired with regard to their arrangement.

They may, like the bones, be described in two ways.

1. *In relation to the median plane of the body;* whence their division into pairs and single muscles. The last, very few in number, are far from exhibiting the symmetry which exists in the bones of the same order, as may be seen in the diaphragm.

2. *In relation to the other organs;* such as the bones and surrounding muscles.

C. Form.—With regard to their absolute form, the muscles, again, like the bones, are classed as long, wide, and short.

Long muscles.—These muscles are more particularly met with in the limbs. Provided with a principal axis, to which we may ascribe the effect of their contraction, they present a *middle portion*—usually thick, and *two extremities* of unequal thickness; the most voluminous, always turned upwards, is metaphorically designated the *head*, the other the *tail*. They are most frequently *fusiform*, sometimes *conical*, but rarely *cylindrical*, *prismatic*, or *flattened* into thin bands.

Thus, as Bichat remarked a long time ago, there are muscles which have no other analogy with the long muscles of the limbs than in their external appearance. These are the long muscles lying above or below the spine, and which are composed of a series of fasciculi indistinguishable at their origin and distinct at their termination; or fasciculi, each of which has a distinct origin or termination on the vertebræ.

Wide muscles.—Wide muscles are those which have two principal axes, and are stretched beneath the skin, or around the great cavities of the trunk, which they concur in enclosing and separating from one another. They are *elliptical*, *quadrilateral*, *triangular*, *trapezoid*, etc.

Short muscles.—These are found chiefly around the short bones, or at the periphery of the articulations which are deeply buried under enormous muscular masses. Although their name indicates that their three axes offer nearly the same dimensions, yet there is most frequently one, and even two, which predominate. They may therefore be assimilated, in this respect, to the long or wide muscles.

D. Direction.—Cruveilhier has justly remarked, that the direction of a muscle is one of the most important features in its history; for it allows the determination of the angle of incidence of the muscle on its arm of the lever, its power, and its uses.

With regard to the direction of muscles, we may observe: 1. The form of their principal axis. 2. The relation of this axis to the vertical line. 3. Its comparison with the axis of the bony levers which the muscles surround or moves.

a. A muscle is termed *rectilinear* when its principal axis is straight; it is *curvilinear*, or *circular*, if this axis describes a curve more or less marked; it becomes *inflected* when it proceeds in a certain direction, and afterwards turns on a bony or cartilaginous pulley in another direction—that is to say, when its principal axis is broken into several lines. If the muscle offers two axes, it will be *flat* or *concave*, these being one or the other, or straight or curvilinear.

b. With regard to the direction of the muscles to that of the plumb-line, it is either *vertical*, *horizontal*, or *oblique*—expressions which carry their own definition and require no explanation.

c. If the direction of the muscles be compared with that of the bones they surround and move, it will be found that they are either parallel to these levers, or form with them angles more or less acute. The proper direction of the bones being known, it is sufficient to indicate that of the muscles to clearly establish this comparison. For instance, in saying that the majority of the muscles of the shoulder are oblique from above to below, and from before to behind, it is understood that these muscles are parallel to the scapula, and that their incidence on the humerus takes place at a right angle.

E. Attachments or Insertions.—This is undoubtedly the most essential part of the study of the muscles; for with a knowledge of their insertions, we may determine their extent and direction, and even their relations and uses.

By the term *attachment*, *fixed insertion*, or *origin*, is meant the point of the muscle which usually remains fixed while the muscle itself contracts; the *attachment*, *movable insertion*, or *termination* is the name given to that portion which is fixed to the lever displaced by the muscular contraction. Muscles are frequently met with the two insertions of which are alternately fixed or movable; and in such cases care is taken not to give these insertions one or other of the designations.

The *fixed insertion* is often confounded with that of other muscles; the *movable insertion* is generally free and independent.

The muscles are sometimes directly attached to the bones by the ends of their fleshy fibres; but most frequently they are fixed to these inert levers through the medium of a tendon or an aponeurosis, the volume of which is less considerable than that of the fibres. But for this arrangement, the surface of the skeleton would not be sufficiently extensive to give insertion to all the external muscles.

F. Relations.—The indication of the relations of the muscles completes the idea of their situation, and is of great importance from a surgical point of view. They should, therefore, be studied with all the precision possible.

The muscles entertain relations either with the skin, the bones, other muscles, or with vessels and nerves.

a. It is only, properly speaking, the subcutaneous muscles—such as the panniculus carnosus and the muscles of the face—which are really in immediate contact with the skin. The others are separated from it by the aponeurotic fascia, which will be described as the appendage of the muscular system.

b. The superficial muscles are only related to the bones by their extremities. Those which are deeply situated are immediately applied by their bodies against the bones of the skeleton.

c. The muscles are related to each other in a more or less intimate manner. Sometimes they adhere closely to one another; and at other times they are separated by interstices filled with fat or connective tissue, and which are generally traversed by vessels and nerves.

d. The connections of the muscles with the latter organs sometimes assume a remarkable character; this is when one of them accompanies, like a *satellite*, the vascular and nervous trunks concealed beneath its deep face. There is in this circumstance an important fact with regard to surgical anatomy. The borders of these muscles are usually visible on the surface of the region, and for this reason may become valuable guides in seeking for important organs in their vicinity.

G. Nomenclature.—*a*. Before the time of Sylvius, the muscles had not received particular names. Since the days of Galen they had been distinguished by the numerical epithets of *first*, *second*, *third*, etc., to indicate their place and their order of superposition in the regions to which they belonged. It is in this fashion that they are designated in the Italian work on the Anatomy of the Horse by Ruini.

b. Sylvius was the first to give the muscles real names; and, his example being followed by succeeding anthropotomists, the nomenclature of these organs was soon completed. But no general view, no methodic spirit, guided Sylvius and his successors; it was sometimes their form, and sometimes their direction (*oblique*, *straight*, *transverse muscles*), position (*intercostal muscles*), uses (*adductor*, *abductor muscles*), etc., to which the muscles owed their names. Bourgelat applied this nomenclature to the Horse, but modified it in many points.

c. Chaussier, struck by the imperfections of the nomenclature introduced into science by Sylvius, sought to substitute for it another, much more methodical. This anatomist gave to each muscle a name formed by two words, indicating the insertions of the organ. Girard imported this ingenious idea into veterinary anatomy. It was in applying this nomenclature to the muscles of the Horse that he gave the name of *supra-acromio-trochanterius* to the *supra-spinatus* of Sylvius and Bourgelat, and *subscapulo-trochanterius* to the *subscapular* of these authorities. When two muscles have the same attachments, they are distinguished by adding to the names which indicate their insertions, another which signifies the relative position or size of these organs. Thus, we distinguish the *long abductor* of Bourgelat from the *short abductor*, both of which would merit the name of *scapulo-humeral*, according to the nomenclature of Chaussier, by the epithets of *great scapulo-humeral* and *small scapulo-humeral*. The binary nomenclature of Chaussier is a useful aid to the memory of students, for a knowledge of the name of a muscle implies that of its attachments and uses; but, nevertheless, notwithstanding its advantages, this new nomenclature did not supersede the old one; because it ceased to be correct when applied to comparative anatomy, the same muscles not having the same insertions in all the species.[1]

[1] It is not, however, that the ancient nomenclature has more advantages in this respect than the new. What can be more improper, for example, than the names of deltoid, splenius, soleus, digastricus, etc.? Do the muscles which receive these designations, considered in Mammals only, offer in all species the form or the structure which justifies the employment of these names in the human species? Are the distinctive epithets of great, medium, little, etc., given to many of them, reasonably applicable in every case? May not the same objection be urged against the majority of the names derived from their uses, complications, etc.?

No system of myological nomenclature is really philosophical, and we are of those who believe it to be indispensably necessary to create one; indeed, we are inclined to think that it would be simple and easy to attain this result in starting from a basis the fixity and invariability of which should be well defined. And this basis is, in our opinion, already discovered; it is the *principle of connections* founded by E. Geoffroy Saint-Hilaire in his immortal *Philosophie Anatomique*—a principle to which modern science certainly owes its finest conquests.

We are desirous that *the myological nomenclature should rest entirely, in the first place, on the relations of the muscles with the bones of the skeleton, or with other organs equally fixed and very important; in the second place, on the reciprocal connections of the muscles.*

Such is our rule; and it is not precisely new, for the older anatomists were often inspired by it, though unwittingly, as the principle on which it is founded was to them entirely unknown; this circumstance, however, immediately leads us to an appreciation of its value. For instance, what could be happier than the name of intercostals given to the muscles situated between the ribs, and their distinction into external and internal? Here we have names which indicate the *relations of the muscles* they designate, *with the portions of the skeleton and the reciprocal connections of these muscles.* It can also be applied in an equally rigorous manner to every species. We may also cite the supra-costals, the intertransverse, the trans-

In this work we will follow the nomenclature of Bourgelat, which will, however, be submitted to some change. But as the names given by Girard are, in our opinion, of some assistance to students, care will be taken to include them in the synonymy.

(It only remains for me to add that Chauveau's nomenclature will be followed as closely as possible. It possesses advantages which are greatly superior to that adopted by Percivall; and as, in my opinion, the names and terms imported into science should be as nearly alike in all languages as may be compatible with circumstances, in order to facilitate study, comparison, and reference, I the more readily venture to take this course. Percivall's nomenclature will, however, be added in brackets to the synonyms, as well as that of Leyh and Gurlt, when occasion appears to demand it.

Structure of the Striped Muscles.

There enter into the structure of muscles: 1. Muscular tissue, properly so called. 2. Connective tissue in the form of delicate lamellæ, aponeuroses, or tendons. 3. Vessels and nerves.

A. MUSCULAR TISSUE.—This tissue is composed of prismatic fasciculi, which it is possible to divide and subdivide into several smaller and smaller fasciculi, until the *muscular fibre* or *primitive fasciculus* is reached.

The *muscular fibre* is a kind of irregular cylinder, from 0·010 to 0·008 millimetres in length. It is sometimes straight, sometimes slightly wrinkled, but always striped either in a longitudinal or transverse direction, or both at once; the transverse striæ, being usually more marked, gives the fibril a very elegant scalariform aspect.

This fibre is formed by an *envelope* and *contents*.

The *envelope* is a very delicate, structureless membrane of an elastic nature, named the *sarcolemma* or *myolemma* (Fig. 146). Flat or oval nuclei in greater or less number can be seen on its inner face.

The *contents*, or *muscular substance*, can easily be resolved into parallel *fibrillæ*

verse spinous, the subscapularis, the supra-spinatus, the infra-spinatus, etc., as they are found in a greater or less marked degree in identical conditions.

Other muscles have received names derived in part from their situation, and in part from their volume. These names are far from being as convenient as the first; as may be judged from the following examples:—

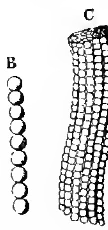
In the majority of vertebrate animals, there are three important muscles situated above and behind the pelvis, and forming the base of the croup; they have been designated *gluteals*, and this name is convenient, because it designates their situation. But to distinguish them from each other, regard has been had to their volume; so that there is a great, a medium, and a small gluteus. This is an error, however, for the volume of the muscles is subject to the greatest variations, and a voluminous muscle in one species may be a very small one in another, and *vice versâ*. The muscle analogous to the gluteus maximus in Man has been described by Bourgelat as the minimus, and by Lafosse and Rigot as the medius. With regard to the gluteus medius of Man, its representative in the lower animals has been designated as the maximus by the majority of veterinary anatomists. What confusion! And how easy it was to evade it by distinguishing these muscles, not by their volume, but by their reciprocal connections, which are the same in every species! Is it not, indeed, more natural to substitute the names of superficial, middle, and deep gluteals, for those of great, etc.?

The same remark is applicable to the muscles which, in Man, cover the anterior aspect of the chest. Designated in common, and justly so, as *pectorals*, these muscles are wrongly distinguished into great and little; for the last, which is already an enormous muscle in the smaller Ruminants, is represented in Solipeds by two considerable muscles, much more voluminous than the muscle analogous to the great pectoral. It is only necessary, in this case, to change their names into superficial and deep pectorals.

in the fresh muscles of insects; in the higher animals, this disassociation into parallel fibrillæ is generally only possible in muscles subjected to the action of certain reagents. Other reagents favour the breaking up of the fibre into superposed discs; hence it has been concluded that the fundamental element of the *primitive muscular fibre* was not a fibril, but a discoid segment of fibrillæ, to which Bowman gave the name of *sarcous elements* (Fig. 143).

Bowman considered that the transverse striæ represent the lines of union of the *sarcous elements.* But nowadays the striation of the fibre is explained by the striation of the primitive contractile cylinders; in fact, each of these is divisible into a series of thick, dark-coloured, contractile discs, joined by bright bands which play the part of a tissue framework in the cylinder. In the majority of Mammals, the thick discs are traversed in their middle by a pale streak named the *intermediate band* or *streak of Hensen;* in the middle of each bright band is a thin disc dividing it into two parts. In the Invertebrata the situation is more complicated, as is seen in Fig. 147.

Fig. 145.



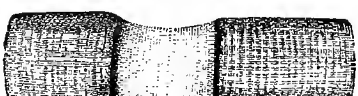
B, ULTIMATE FIBRIL OF MUSCLE (ACCORDING TO BOWMAN).

C, Muscular fibre more highly magnified, its myolemma being so thin and transparent as to allow the ultimate fibrillæ to be seen.

Ranvier has remarked that there is, in the Skate and Rabbit, pale and dark striped muscles. The pale muscles are recognized by the predominance of the transverse striation and the rarity of nuclei; while the fibres of the dark muscles present, on the contrary, a great number of nuclei and prevailing longitudinal striation. Lavocat and Arloing have examined these differences in the muscular apparatus of some Fishes, Birds (Fowls, Guinea-fowls), and domestic Mammals (Dog, Ox, Horse), and their observations confirm those of Ranvier, apart from some secondary differences special to the varied species on which they made their investigations.

The muscular fibres are united parallel to each other to form secondary fasciculi, which are surrounded by a connective sheath—the *internal perimysium.* The secondary fasciculi are laid together to constitute more voluminous fasciculi, which, in their turn, form the entire muscle. The connective sheath enveloping the muscle is named the *external perimysium.*

Fig. 146.



MUSCULAR FIBRE BROKEN ACROSS, SHOWING THE UNTORN SARCOLEMMA CONNECTING THE FRAGMENTS.

B. Tendons and Aponeuroses.—The *tendons* are white, nacreous, round, or flattened cords fixed to the extremities of the long muscles. They are composed of fasciculi of connective-tissue fibres, covered by a layer of flat cells; they have a parallel direction, and are united to one another by loose connective-tissue sheaths.

The elementary fibres succeed the primitive striped fibres; the latter terminate in rounded extremities, and are fused to the fibrous fasciculi—hollowed into a kind of cup—by an intermediate and very solid amorphous substance.

The *aponeuroses* belong almost exclusively to the wide muscles; they are formed of several planes of parallel fibres which are not intercrossed in their middle part; at their superficies, however, the fibrous fasciculi are matted together in a more or less inextricable manner.

It is very interesting to study the mode of union of the muscular fibres with the tissue of the aponeuroses and tendons, as well as the reciprocal relations of these two parts.

The muscular fibre may be found passing in the same direction as the tendon, or it may fall upon the latter obliquely. In both cases there is no insensible

Fig. 147.[1]

PRIMITIVE FIBRE OF THE RED MUSCLE OF A RABBIT, MADE TENSE BY THROBBING.

NS, Superficial nuclei; NP, deep nuclei; N, nuclei in profile beneath the sarcolemma; GS, sarcodic drop resulting from the expression of the muscular plasma, due to the contraction of the muscle under the influence of alcohol; G, G, G, proteic granules from the muscular plasma, pressed out and united beneath the sarcolemma, or squeezed outside of it.

Fig. 148.[2]

TORN MUSCULAR FIBRE: THE TWO FRAGMENTS ARE HELD TOGETHER BY THE SARCOLEMMA.

transition between the muscular fibre and the fasciculus of the fibrous tissue; on the contrary, the contractile fibre terminates by a rounded extremity, which is buried in a corresponding depression in the tendon or aponeurosis. The union of the muscular with the fibrous tissue appears to be effected by means of a kind of amorphous cement, which is very solid; so much so, that when the muscles are submitted to a degree of traction sufficient to cause a rupture, this never happens at the point of union.

The tendons commence sometimes by a hollow cone, which receives on its internal face the insertions of its muscular fibres; and sometimes by a thin point, often divided, which is plunged into the substance of the muscle. It is worthy of remark, that a muscle provided with two tendons shows the first-named arrangement at one of its extremities, and the other at its opposite extremity; so that all the fibres which compose the muscle offer nearly the same length, those which leave the summit of the internal tendon being fixed to the bottom of the hollow cone formed by the second tendon, and so on reciprocally.

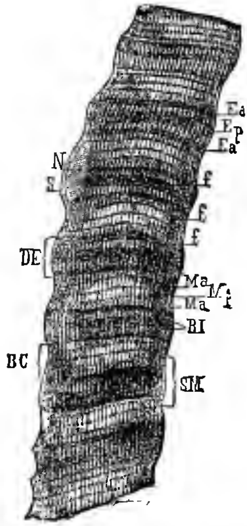
Tendons are not necessarily placed at the extremities of muscles. Sometimes the muscle is divided into two bodies or bellies by a middle tendon; it is then named a *digastric* muscle:

[1], [2] These figures are from Renaut's work, *Traité d'Histologie*. Just published by Lecrosnier, Paris.

The muscular fibres which are continued by the fibrous fasciculi may be divergent or parallel. In the first case—the diaphragm, for example—the connective fibres run in the same direction as the muscular fibres. In the second case several arrangements may be observed :

1. Tendons may pass in the same direction as the muscular fibres. This is the most simple manner (Fig. 152, A).

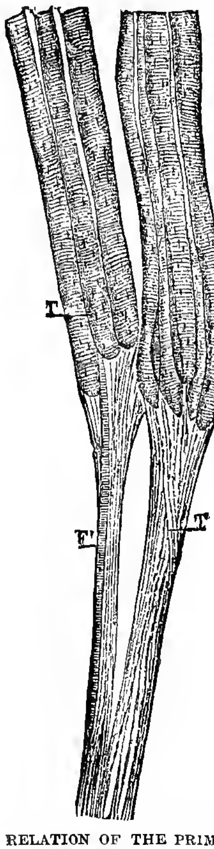
Fig. 149.



PRIMITIVE MUSCULAR FIBRE FROM THE FOOT OF THE LUCANUS STAG-BEETLE—A COMPLICATED CONTRACTILE SEGMENT, MADE TENSE BY THE INTERSTITIAL INJECTION OF STRONG ALCOHOL.

N, Muscular nucleus ; S, sarcolemma ; SM, limits of a contractile segment of muscular substance ; DE, limits of a thick disc system enclosing discs ; *Ep*, principal thick disc ; *Ea*, *Ea*, thick accessory discs ; BI, intervening bright bands of the thick discs ; BC, limits of the system of the bright band containing—*Mp*, the thin principal disc, and *Ma*, *Ma*, the two thin accessory discs ; *f*, *f*, *f*, lines of longitudinal striation indicating the limits of the fibrillar fasciculi.

Fig. 150.[1]



RELATION OF THE PRIMITIVE MUSCULAR FIBRES WITH THE TENDON OF THE STERNO - HYOID MUSCLE OF THE FROG.

F, Ordinary primitive fibres ; F′, muscular prolongation ; T, tendon of insertion.

2. Muscular fasciculi, passing altogether from the same side to become united into a tendinous cord (Fig. 152, B and C), constitute a *semi-penniform* muscle.

3. Muscular fasiculi may be implanted to right and left of the tendon, and form a *pennated* or *penniform* muscle (Fig. 152, D).

These various arrangements of the muscular fibres with their tendons demonstrate the necessity of not confounding the length of the fleshy body of a muscle

[1] From Renaut's work already mentioned.

with the length of its fibres; for the latter alone give an indication of the possible degree of shortening it is capable of—this shortening being estimated at one-fourth the length of its contractile fibres. In glancing at the different arrangements shown in Fig. 152, it will be seen that, with muscles which have the same total length, that of the contractile elements varies within extensive limits.

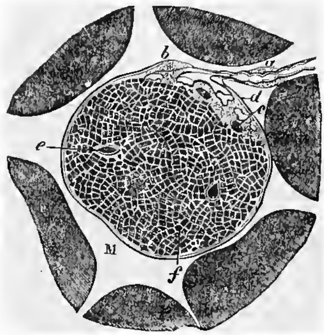
C. VESSELS AND NERVES.—The *muscular tissue* receives much blood; the fibrous tissue very little. The *arteries* are large and numerous, and each is accompanied by two *veins*. The capillary vessels anastomose in such a manner as to form rectangular meshes, the greatest diameter of which is directed towards the length of the muscle.

Ranvier has remarked that, in the dark muscles of the Rabbit, the vascular network has varicose formations which retain a considerable mass of blood in the interior of the muscles.

The *lymphatic vessels* of the muscles are few; they sometimes penetrate their interior in following the capillaries; at other times they remain on the surface, in the external perimysium. The existence of lymphatics has not yet been demonstrated in tendons, aponeuroses, or synovial membranes.

The *nerves* emanate from the cerebro-spinal centre. At their terminal extremity they offer a small enlargement, called by Rouget the *motor end plate*, and by Doyère and Kühne the *nervous colline* (hillock). It is admitted that the motor tube traverses the sarcolemma, there losing its envelope; and that the substance of the axis-cylinder is spread over the surface of the muscular fibrillæ to form the motor plate.

Fig. 151.



TRANSVERSE SECTION OF FROZEN MUSCLE, MAGNIFIED 400 DIAMETERS.

N, Nerve. M, Muscular fibre, surrounded by portions of six others: *a*, nucleus of the nerve-sheath; *b*, nucleus of the sarcolemma; *c*, section of nucleus of terminal plate of nerve; *d*, transverse section of terminal plate, surrounded by granular material; *e*, transverse section of muscle nuclei; *f*, fine fat-drops. The angular dark particles are sections of sarcous elements; the clear intervening spaces represent the fluid isotropal part of the muscle substance.

Physico-chemical Properties of Striped Muscles.

Muscles are soft organs, remarkable for their more or less deep-red colour, which varies with the species, and even with the age and health of animals of the same species.

By desiccation, muscles become hard and brown; by repeated washing they assume a straw-yellow tint.

Muscles are extensible, elastic, and tenacious; and their tenacity is more marked during life than after death.

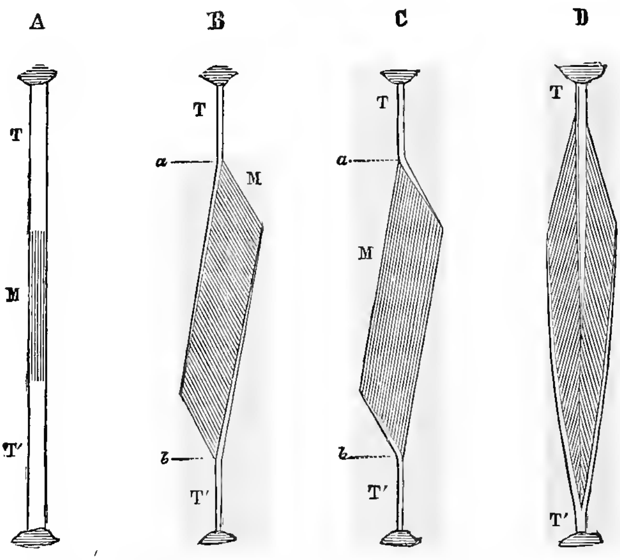
It has been remarked that the juice impregnating the muscular tissue has a marked acid reaction when extracted from a muscle which has been actively contracting. (The fluid or "muscle plasma" obtained by pressing flesh, is either neutral or slightly alkaline. It soon coagulates and separates into two portions—a semi-solid portion, "myosin," and the fluid serum that at ordinary temperatures quickly acquires an acid reaction.) It holds in solution a variable quantity of albumen, casein, fat, a little creatine, creatinine, and a somewhat large proportion of sarco-lactic acid. The solid substance of the muscle may be partly transformed into gelatine by boiling in water; but its largest portion is a nitrogenous substance, soluble in dilute hydrochloric acid, called *myosine*, or muscular fibrine; it differs but little from the fibrine of the blood.

Physiological Properties of the Striped Muscles.

In this paragraph will be discussed the development of the muscles, muscular contractility, and the part the muscles play in locomotion.

A. Development of the Muscles.—A muscle is derived from a mass of embryonic cells. Each cell becomes considerably elongated, and its nucleus multiplies, the nuclei extending along the course of the fibre. The cellular membrane, enormously developed, forms the sarcolemma; while the contents of the cell, becoming more dense, divide longitudinally, and give rise to the *sarcous elements*. When the muscles are formed, they grow by the augmentation in length and thickness of their primitive fibres.

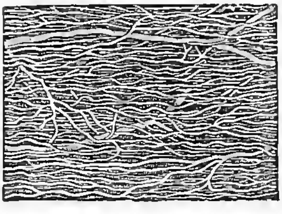
Fig. 152.



ARRANGEMENT OF THE FIBRES OF A MUSCLE.

M, Body of a muscle. T, T′, Tendon. *a*, *b*, Length of the body of the muscle. A, B, C, D, Various modes of arrangement of the muscular fibres. (From Beaunis and Bouchard's *Anatomie descriptive.*)

Fig. 153.



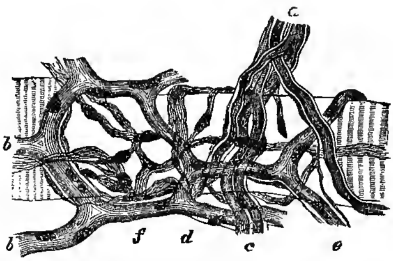
DISTRIBUTION OF CAPILLARIES IN MUSCLE.

B. Muscular Contractility.—Muscles possess the property of contracting under the influence of a natural or artificial stimulus. *Muscular contraction* is the phenomenon resulting from the operation of this property. Muscles in a state of contraction are the seat of physical and chemical phenomena; they change their form and consistence, and produce a relatively abundant quantity of carbonic acid, creatinine, and inosinic acid. During contraction, it has been remarked that the muscular fibres contract by increasing in volume, like an india-rubber tube left to itself after being inflated, and that the transverse striation becomes much closer; though the zigzag doubling mentioned by Prevost and Dumas has not been observed.

But these physical and chemical modifications, important as they are from a physiological point of view, cannot longer be dwelt upon here. It is particularly important to speak of muscular contraction.

A muscle that contracts becomes shortened; its two extremities approach each other if they are free; or one draws near the other if the latter is fixed to an immovable point. If the extremities of a muscle are attached to two movable levers, its contraction will bring about the displacement of one or other of these; from this a movement is produced.

Fig. 154.



PORTION OF AN ELEMENTARY MUSCULAR FIBRE, WITH FOUR DARK-BORDERED FIBRES (*a*) CROSSING ITS SURFACE.

b, Capillary blood-vessel, with fine nerve-fibres (a few only of the transverse markings of the muscle are represented); *c*, two of the dark-bordered nerve-fibres passing over the elementary fibre to be distributed to adjacent fibres. This arrangement, in which a dark-bordered nerve-fibre, distributed to muscle, divides into branches, one of which passes to a vessel, while the other ramifies upon a muscle, is frequent. Magnified 700 diameters.

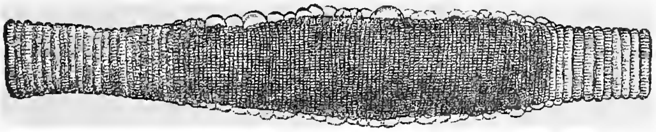
The degree of shortening of a muscle varies, according to its being entirely free, or having a resistance to overcome. The mean limit of this shortening is about one-fourth the length of the muscular fibres. From this it will be understood, that the movement produced by the contraction will be in proportion to the length of the fibres; though in this appreciation it will be necessary to keep in mind the density and energy of the fibre, as well as the intensity of the stimulation which induces the contraction.

As each fibre represents a force independent in its action, it results that the power of a muscle may be inferred by the number of its fibres, or its volume.

Muscles are often aided in their action by mechanical conditions: such as the disposition of the levers on which they act, the direction of the muscular fibres in connection with these levers, and, lastly, by the presence of bands or elastic cords.

C. Uses of Muscles.—There are *flexor*, *extensor*, *abductor*, *adductor*, *rotator*,

Fig. 155.



MUSCULAR FIBRE IN A STATE OF CONTRACTION IN THE CENTRE; THE STRIÆ APPROXIMATED, THE BREADTH OF THE FIBRE INCREASED, AND THE MYOLEMMA RAISED IN VESICLES ON ITS SURFACE.

and other muscles, for all the movements of which the articulations are the centre.

To determine the uses of the muscles, it is sufficient to know their insertions and the mode in which the bones furnishing these insertions articulate with each other.

For example, if a muscle is situated in an angle formed by two bones which have a trochlean articulation, it will be a *flexor*; but if it is placed behind the summit of the angle, it becomes an *extensor*; if it be located on the external side of an énarthrosis, it is an *abductor*; and when on the inner side of the joint, or between it and the middle plane of the body, it is then an *adductor*. A muscle may be rolled obliquely round the joint it controls—in passing, for instance, from the inner face of one bone to the outer face of another forming an articulation—and in such a case the *flexors* and *extensors* become also rotators if the diarthroses they move permit rotation.

Lastly, muscles applied more or less obliquely on bones united by a trochoid, will pivot one of the bones on the other—for instance, the great oblique muscle of the head.

It is useless to multiply examples, for, the principle being once understood, it is easy in nearly every case to determine the uses of a muscle when its situation, and the number and kinds of articulations included between its insertions, are known.

The result of the contraction of muscles being influenced by the form of their principal axis, and the length and direction of their levers, it is necessary to briefly examine these two points:

1. The immediate effect of the contraction of *rectilinear* muscles is the approximation of the bones to which they are attached. This approximation is usually brought about by the displacement of a single bone—that which receives the movable insertion of the muscle. Sometimes, however, the two bones move simultaneously, or they are alternately fixed and movable.

The first result produced by a *curvilinear* muscle, is the straightening of its component fibres; after which it may act on the bony levers as do the rectilinear muscles, if its contractile power be not entirely expended. When a muscle is quite *circular*, its only action is to contract the opening it circumscribes.

With regard to the *inflected* muscles, their action can only be estimated from their point of inflection; they operate as if this point represented their origin or fixed insertion.

2. The muscular powers are submitted to the statical and dynamical laws which govern the theory of levers; for the bones are only levers moved by the muscles.

In the locomotory apparatus we find the three kinds of lever recognized by physicists. Thus the head, extended by the great complexus muscle, represents an *interfixed*, or lever of the first class; the foot, extended by the gastrocnemius muscle, offers an example of the *inter-resisting*, or second kind, when the limb remains fixed on the ground; lastly, the lower jaw, raised towards the upper by the masseter muscle, forms an *interpuissant*, or third kind.

It is worthy of remark that the arm of resistance in the bony levers is always extremely long; a circumstance which favours speed and the extent of movement, but at the expense of power.

On the other hand, muscles are rarely perpendicular to the arm of their levers—at least at the commencement of their action; a second circumstance which diminishes their energy.

Appendages of the Muscles.

These are: 1. The enveloping or containing aponeuroses. 2. The serous or mucous bursæ. 3. The tendinous and synovial sheaths.

A. Containing Aponeuroses.—These are layers or *fascia* of white fibrous tissue, which envelop, in common, all the muscles of one or several adjoining regions—principally those of the inferior bones of the limbs, where they constitute a kind of hollow cylinder.

The aponeuroses are formed of very resisting interwoven fibres, which are attached to the bones at numerous points. At their periphery they receive the insertion of one or several muscles, which keep them more or less tense. Their external face is in contact with a thin connective-tissue layer that separates them from the skin. The internal face sends lamellar prolongations between the muscles, which enclose these in special sheaths.

The aponeuroses maintain the muscles in their position, and sustain them during their contraction.

B. Serous Bursæ.—The serous or mucous bursæ are small cavities, filled with a serous fluid, which are met with at those points where the muscles glide over resisting surfaces. They are generally orbicular or circular, and their interior is often divided by fibrous bands.

Their walls are formed by slightly condensed connective tissue, and may be lined by a pavement epithelium; in which case it is believed that the serous bursa is produced by the simple dilatation of one of the connective-tissue meshes.

They become much enlarged when pressure or friction is great at the points where they are situated. They may appear in any region, when the conditions which preside at their physiological development are accidentally produced.

C. Tendinous Sheaths and Synovial Membranes.—*Tendinous sheaths* is the name given to the half-bony, half-fibrous, sometimes exclusively fibrous, gliding grooves in which tendons play when they are inflected to change their direction, or when they glide over movable articulations.

The *tendinous synovial sheaths* are serous membranes lining the tendinous sheaths, and covering the tendons at the points where these two parts are in contact. They secrete a synovial fluid quite like that of the articulations.

When they almost completely envelop the tendon, and are afterwards carried to the walls of the sheath, they are termed *vaginal*.

Their walls are composed of: 1. A very fine connective-tissue membrane, confounded on its external face with the tendinous sheath, by the other face with the tendon. 2. A simple layer composed of pavement epithelium, extended over the whole or a part of the internal face of the membrane.

Manner of Studying the Muscles.

A. Classification.—To facilitate the study of the muscles, two methods may be employed in grouping them. The first consists in classifying them according to their uses; describing, for example, all the flexors, extensors, etc., of the same region. In the second method, the uses of the muscles are not taken into account, their relations only being considered; and they are divided into groups or *regions*, which include all the muscles situated around a bone. The latter is the method now adopted, because it is the most convenient, useful, and rational.

B. Preparation.—We will limit ourselves to some general remarks on the following points:—

Choice of a subject.—If there is for disposal a certain number of subjects from among which it is possible to make a selection, the preference should be given to those which have the muscular system best developed; not that large, soft, lymphatic Horses with enormous masses of muscle should be chosen, for these animals are always less convenient than small or middle-sized, well-bred Horses. Asses and Mules, when very emaciated, answer well for the preparation of the muscles.

Position of the subject.—It is necessary to place the subject, immediately after death, in a convenient position, in order that the cadaveric rigidity may set in while it is in that attitude.

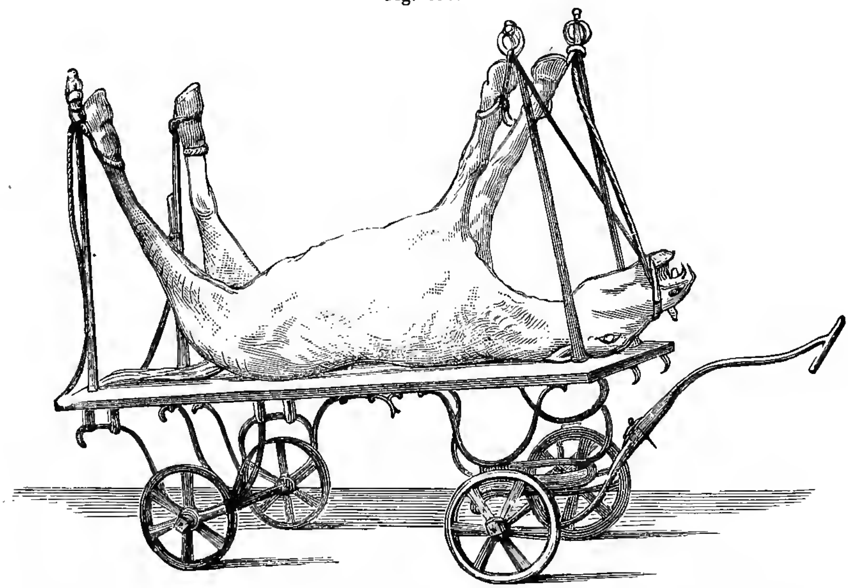
Without this precaution, the various parts of the body may assume an inconvenient shape or direction, and all attempts to amend them will prove almost unavailing, particularly in the larger animals.

Three principal positions may be given to subjects:

1. The animal is in the *first position* when it is placed on its back, the four extremities in the air, and maintained in that posture by means of long cords passed round the pasterns, and fixed to the movable rings which terminate the extremity of the four bars of the wheeled table on which the subject is laid. The head should be beyond the end of the table and rest upon a stool. The animal should always be placed in such a manner that the head be opposite the fore-part of the table, so that the movements of the pole or shaft be not impeded during the displacement of the apparatus. In order that the neck be not twisted to the right or left, in attaching the fore limbs the subject should be raised so that the withers rest lightly on the table. According to the bulk of the animal and the length of the bars, the ropes should be passed around either the pasterns, above the fetlocks, or even above the knees (Fig. 156).

2. To place the animal in the *second position*, it is turned on the belly, the two thighs flexed, the extremities carried beyond the table, and the head fixed between two bars by means

Fig. 156.



HORSE FIXED IN THE FIRST POSITION ON ONE OF THE WHEELED TABLES IN USE AT THE LYONS VETERINARY SCHOOL.

of a rope passed under the zygomatic arches; or better, two cords with metal hooks may be employed, a hook being fixed into each orbital arch, or through the skin and masseter muscle to beneath the zygomatic arch, the cords being tied short to the uprights of the table (Fig. 157). A block of wood or small stool may be employed to prop the trunk by placing it in the sublumbar region (Fig. 157).

3. The subject is in the *third position* when it rests on its side.

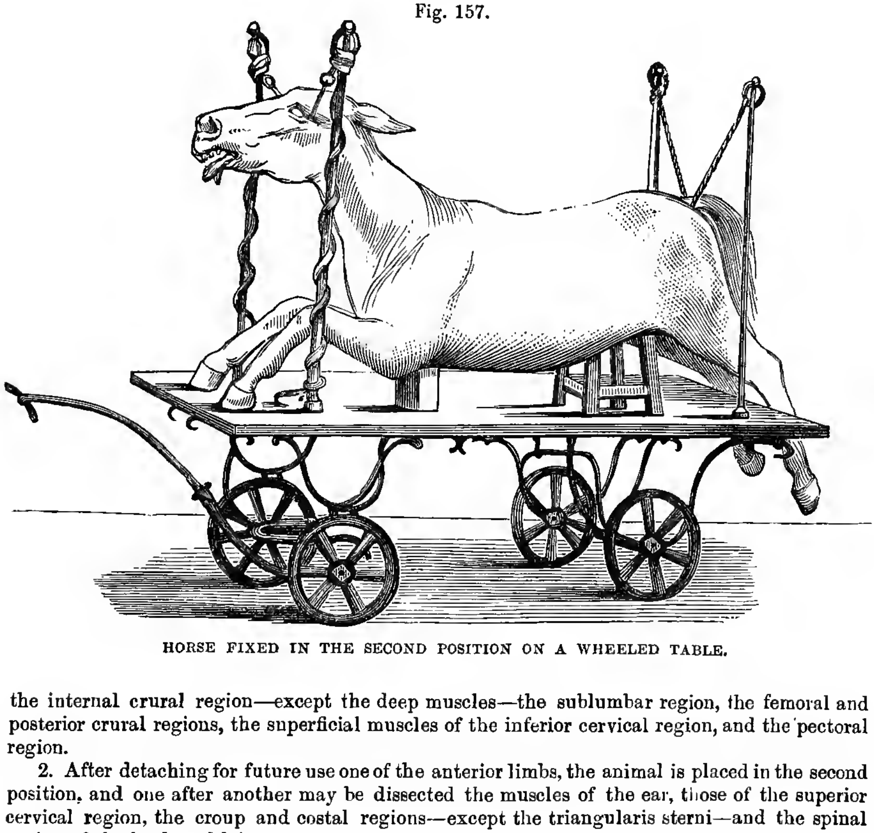
Rules to be observed during the preparation.—1. By no means, if possible, remove the skin from the regions to be dissected until quite ready to begin the dissection. If this is impossible, then take the precaution of enveloping these regions in damp cloths, or in the animal's skin, to prevent desiccation of the aponeuroses and the superficial muscles.

2. To dissect a muscle, it is necessary to remove the aponeuroses or the other muscles which cover it, the connective tissue enveloping it, and the fat, glands, vessels, and nerves lodged in the neighbouring interstices. The aponeuroses should be removed in shreds by making them very tense with the forceps, but without raising them, and causing the blade of the scalpel to glide between the fibrous and muscular surfaces, keeping it always parallel to these two planes. The

covering muscles should not be entirely excised, but ought to be cut through the middle, across their fibres, and the ends thrown back; in this way it is always possible to replace a muscle by bringing the two portions together; the study of its relations is then much more easy. The cellular tissue is got rid of by removing it with the forceps, and carrying the edge of the scalpel in the re-entering angle formed by the cellular layer and the surface of the muscle. This method also suffices for removing aponeuroses when they are slightly adherent to the muscular fibres. But when they give attachment to these by their under face, as may be noticed in the external scapular aponeurosis, it is necessary to have recourse to the method indicated above. To remove fat, glands, etc., scissors will be found very advantageous.

Order to follow in preparing all the muscles of the same subject, so as to derive most advantage therefrom. 1. Place the subject in the first position, and commence by studying the muscles of the inferior abdominal region. Then excise them, leaving the posterior extremity of the deep pectoral muscle, the prepubic tendon, and the crural arch intact. The abdominal cavity having been emptied of the viscera it contains, dissect and study successively the diaphragm,

Fig. 157.



HORSE FIXED IN THE SECOND POSITION ON A WHEELED TABLE.

the internal crural region—except the deep muscles—the sublumbar region, the femoral and posterior crural regions, the superficial muscles of the inferior cervical region, and the pectoral region.

2. After detaching for future use one of the anterior limbs, the animal is placed in the second position, and one after another may be dissected the muscles of the ear, those of the superior cervical region, the croup and costal regions—except the triangularis sterni—and the spinal region of the back and loins.

3. The regions of the anterior limb may be prepared at the same time, or immediately afterwards.

4. Separate the two posterior limbs by sawing the femurs through their middle, and proceed to the dissection of the muscles of the posterior leg and foot.

5. By means of another application of the saw across the middle of the loins, the pelvis is completely isolated for the preparation of the coccygeal muscles, and the deep muscles of the internal crural region, nearly as they are represented in figures 39 and 40.

6. The animal being placed on its side, the pectoral cavity is opened by sawing through the ribs near their extremities; on the two particular portions thus obtained may be studied, in one part, the triangularis sterni, and in the other the deep muscles of the inferior

cervical region, including the longus colli and the anterior and lateral straight muscles of the head.

7. Lastly, the head is disarticulated and the muscles of this region are prepared.

The subject may afterwards serve for the study of nearly all the articulations.

Preservation of the muscles.—The muscles may be preserved by immersing them in appropriate fluids, and the muscular preparations by drying them.

A large number of liquids preserve muscles from putrefaction. We may mention alcohol; a mixture of alcohol and oil of turpentine; alcohol, water, and chloroform; a solution of sulphate of iron, bichloride of mercury, or arsenious acid. The best preservative fluid, however, is nitric acid diluted with water, in the proportion of one of the former to three of the latter. The acid hardens the muscles and softens the connective tissue; this allows all the interstices to be completely cleared out, and even permits the primitive muscular fasciculi which have been concealed by the white tissues, to be exposed.

Desiccation, after immersion in a bath of arsenious acid or sulphate of iron, causes the muscles to become hardened and distorted. It is therefore a bad procedure, though it preserves the muscles. Steeping in carbolized glycerine is sometimes resorted to.

(A careful dissection of the muscles, with regard to their origin, insertion, action, and relations, is of infinite importance to the student of human anatomy; to the Veterinary Student it is no less important, and more particularly with reference to the muscles of the limbs. A correct knowledge of their situation, attachments, and functions is often the only guide the Veterinary Surgeon can rely upon in the diagnosis of those apparently obscure cases of lameness which are of such comparatively frequent occurrence. In the words of Mr. Henry Gray, we may repeat that "an accurate knowledge of the points of attachment of the muscles is of great importance in the determination of their action. By a knowledge of the action of the muscles, the surgeon is able at once to explain the causes of displacement in the various forms of fracture, or the causes which produce distortion in the various forms of deformities, and, consequently, to adopt appropriate treatment in each case. The relations also of some of the muscles, especially those in immediate apposition with the larger blood-vessels, and the surface markings they produce, should be especially remembered, as they form most useful guides to the surgeon in the application of a ligature to these vessels" (*Anatomy, Descriptive and Surgical*).

An accurate knowledge of the muscular system is also of great service to the Veterinary Surgeon, in estimating the value to be placed upon the external conformation presented by animals intended for different kinds of labour.

"In dissecting," says Mr. Holden, "there are four principal objects to be constantly borne in mind by the student: 1st, The impression on the memory of those facts of general anatomy taught in the lectures. 2nd, The study of those parts of the body more especially concerned in surgical affections and operations. 3rd, The education of the sense of touch, and of the hand in the use of instruments; and 4th, The education of the eye in the knowledge of the several tissues of the body, in various positions, and varying circumstances. . . . The education of the eye is a gradual and tedious process, but one which is pretty certain to be satisfactorily accomplished if the student do but use his hands properly, and therefore a few words on the manual part of dissection may not be out of place.

"First, as to the instruments requisite for dissection. A case, containing six or eight scalpels, two pairs of scissors, a pair of dissecting forceps, a set of chain-hooks, a blow-pipe, and a probe, will enable the student to make all requisite dissections, supposing that he is allowed the use of a saw and chisel in the dissecting room. Great variety exists in dissecting-cases, both as to form and expense, but so long as the instruments themselves are strong and good, the simpler the case the better. Scalpels for dissection are made of two principal shapes; in one, the edge is bevelled to the point, the back being straight; in the other, both back and edge are bevelled to a point midway between the two. The latter form is preferable for most purposes. The blade should not be more than an inch and a half long, and never double edged; but the material of which the handle is constructed is a matter of indifference.

"For all ordinary dissection, it will be found most convenient to hold the scalpel like a pen; but for cleaning the fascia off muscles and following out small nerves, it is better to hold it reversed, so that the *back* of the knife may be against the tissue which is to be preserved. In making the first incision through the skin of a limb, or in any other position where a long incision is required, the knife may, with advantage, be held *under* the hand, by which the wrist has more play, and the student has the opportunity of practising a mode of holding the knife which he will find very useful when operating on the living body.

"The forceps should be broad at the extremities and coarsely serrated, so that it may retain a firm hold on small portions of tissue. It is very important that the forceps should not be too strong in the spring, for in that case it becomes so fatiguing to the hand that it is impossible to continue its use for any length of time. The forceps should be held lightly between the thumb and the first and second fingers of the left hand, which may be steadied by resting the little finger on a neighbouring part.

"The chain-hooks should be strong, and bent in the direction of the thickness and not of the breadth of the steel, as is sometimes done. These latter are very inferior, being liable to be unbent under any considerable strain. Care should be taken that the chains are firmly linked, and that the central ring is sufficiently stout to bear any force that may be applied. The scissors should be large and strong, and it will be found advantageous to have one curved pair, which is very useful in preparing the ligaments.

"The student will do well to bear in mind that he will probably be called upon in after life to operate on the living body, the only preparation for which is careful dissection: he should therefore, as far as possible, conduct all his dissections as methodically, and with as much care, as if operating on the living body.

"The student should bear in mind that his manual labour is only a part of his duty, and will be thrown away, unless he at the same time study the description of the part upon which he is engaged; he should not, therefore, carry the dissection further than he can learn the description on the same day, *and at the subject*, and should, if possible, re-peruse the description in the evening, and always on the next morning, before carrying the dissection any further.")

CHAPTER II.

THE MUSCLES OF MAMMALIA IN PARTICULAR.

Article I.—Muscles of the Trunk.

Subcutaneous Region.

This only comprises a single muscle, the *fleshy panniculus* (*panniculus carnosus*), which moves the skin covering the trunk. Strictly speaking, however, we may describe as dermal muscles all those which are attached to the inner surface of the superficial integument—the muscles of the face, for example.

Fleshy Panniculus (Panniculus Carnosus).

Preparation.—Place the animal on its side, and carefully remove the skin, allowing the panniculus muscle to remain on the subjacent muscles. It may also be easily prepared on the subject placed in the first position.

Situation—Form—Extent.—Situated on the inner surface of the skin covering the sides of the thorax and abdomen, this is an immense wide muscle, irregularly triangular in shape, thin at its borders, and thicker in the middle than elsewhere.

The upper border corresponds to a curved line, convex superiorly, and extending obliquely from the flank to the withers. The inferior border is carried horizontally from the flank to the posterior border of the olecranian mass of muscles, passing along the upper margin of the deep pectoral muscle, which it covers, and to which it adheres somewhat closely. The anterior border descends from the superior extremity of the shoulder on to the muscles of the forearm.

Structure—Attachments.—The fibres of this muscle are directed forwards for its posterior two-thirds; but on arriving on the shoulder they gradually become vertical. They are continued, on the margins of the muscle, by aponeuroses which attach it either to the internal surface of the skin, or the fibrous fascia of the superficial muscles.

This muscle has, besides, a very remarkable insertion into the humerus, which was noticed by G. Cuvier, in his 'Leçons d'Anatomie Comparée,' and which appears to have been omitted, at least so far as Solipeds are concerned, in every treatise on Veterinary Anatomy. The following is what we have often observed in this respect: On reaching the posterior border of the ulnar mass of muscles, the panniculus divides into two superposed layers—one, superficial, is carried to the muscles of the anterior limb; the other, deep, soon terminates by an aponeurosis, which is united to the deep pectoral muscle, and is bordered at its upper margin by a nacrous aponeurotic band that penetrates between the thorax and the muscles of the arm, to be fixed to the small trochanter.

Relations.—By its superficial face, with the skin, to which it closely adheres; by its deep face, with the latissimus dorsi, the dorsal portion of the trapezius, the abdominal tunic, the great oblique muscle of the abdomen, the serratus magnus, some external intercostals, the spur vein, and the superficial muscles of the shoulder and arm.

Action.—The animal, in contracting this muscle, shakes the whole of the cutaneous integument which covers it; thus preventing insects from alighting on the surface of the body, or tormenting by their bites or stings.

In the **Dog**, the panniculus carnosus is prolonged over the croup, and is united along the dorso-lumbar spine to that of the opposite side. It is very developed in the **Cat**.

Cervical Region.

This region comprises all the muscles grouped around the cervical vertebræ—muscles which are conspicuous by their volume, and the important part they play in the animal economy. There are described a *superior* and an *inferior cervical region.*

A. Superior Cervical, or Spinal Region of the Neck.

This includes seventeen pairs of muscles, arranged in four layers on each side of the cervical ligament, as follows:—

First Layer.

Cervical portion of the Trapezius.

Second Layer.

Rhomboideus. Angularis scapulæ. Splenius.

Third Layer.

Complexus. Trachelo-Mastoideus.

Fourth Layer.

Spinalis or *Semispinalis Colli. Six Intertransversales Colli. Obliquus Capitis anticus* or *inferioris. Obliquus Capitis posticus* or *superioris. Rectus Capitis posticus major. Rectus Capitus posticus minor.*

These occupy the triangular space circumscribed by the upper border of the cervical ligament, the transverse processes of the vertebræ of the neck, and the spinous process of the second dorsal vertebra.

Preparation.—Place the subject in the second position, and dissect in succession the four layers of the region. To study the first layer, which is formed by the cervical portion of the trapezius, remove the skin, connective tissue, and the fascia covering that muscle (see Fig. 159). The preparation and study of the second layer, composed of the rhomboideus, angularis, and splenius, is carried out in two stages. In the first, the trapezium and the mastoido-humeralis is removed, leaving only the cervical insertions of the latter muscle; then the limb is removed by sawing through the scapula beneath the insertions of the angularis and serratus magnus, as in Fig. 162. But as neither the cervical or dorsal insertions of the splenius are exposed, it is necessary to proceed to the second part of the operation by removing the rhomboideus, angularis, and the superior extremity of the shoulder. To prepare the third layer, which comprises the great and small complexus, it is sufficient to excise the splenius, in following the direction of the neck, and to turn upwards and downwards the two portions of the muscle (see Fig. 162). Lastly, the deep layer—the semispinalis and intertransversalis, oblique, and posterior straight muscles, as well as the cervical ligament—is exposed by removing the complexus and longissimus dorsi muscles (see Fig. 162).

First Layer.

Cervical Portion of the Trapezius.

For description of this muscle, see *Spinal Region of the Back and Loins.*

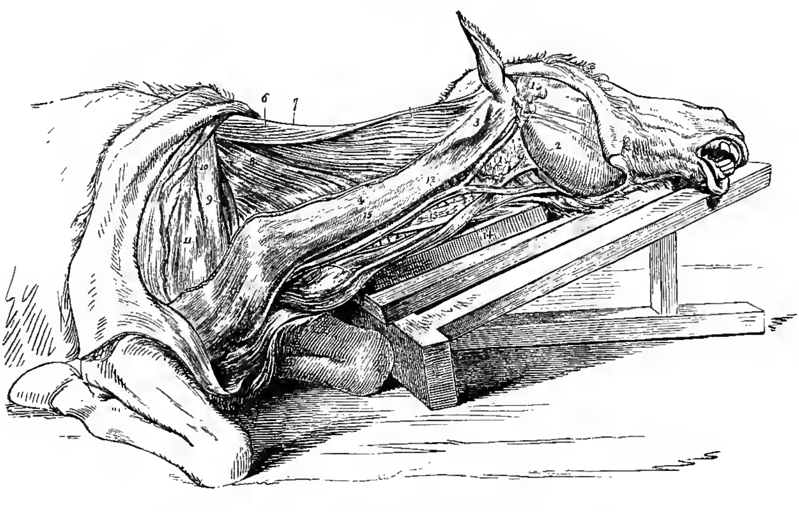
Second Layer.

1. Rhomboideus (Figs. 158, 6; 162, 1, 2.)

Synonyms.—Described by Bourgelat as two muscles, the *proper elevator of the shoulder* and the *rhomboideus*, these were termed by Girard the cervico-subscapularis and dorso-subscapularis. (This is the *rhomboideus longus* and *brevis* of Percivall, and the *dorso-scapularis* and *cervico-subscapularis* of Leyh.)

Form—Situation—Direction.—This muscle has the form of a very elongated triangle, and is situated at the inner aspect of the cervical trapezius and the

Fig. 158.



LATERAL VIEW OF THE NECK; SUPERFICIAL MUSCLES.

1, 1, Parotid gland; 2, sterno-maxillaris, and, 14, its junction with its fellow of the opposite side, 3, 4, mastoido-humeralis, or levator humeri; 5, splenius; 6, rhomboideus; 7, funicular portion of the cervical ligament, or ligamentum colli; 8, angularis of the scapula; 9, supra- or antea-spinatus; 10, trapezius; 11, infra- or postea-spinatus; 12, jugular vein; 13, subscapulo-hyoideus; 15, trachea.

scapular cartilage, beneath the cervical ligament, the direction of which it follows.

Structure—Attachments.—It is composed of thick fleshy fasciculi, the anterior of which are oblique downwards and backwards, the posterior passing directly downwards. These fasciculi are fixed by their superior extremity to the funicular portion of the cervical ligament and the summits of the spinous processes of the four or five dorsal vertebræ succeeding the first—*fixed insertion*; by their inferior extremity, to the inner aspect of the scapular cartilage, where the anterior fasciculi are confounded with those of the angularis.

Relations.—Covered by the cervical portion of the trapezius, the scapular cartilage, and the aponeurosis of the latissimus dorsi muscle, the rhomboideus covers the sphenius, which is excavated near its superior border for its reception, as well as the aponeurosis of the serratus anticus muscle through the medium of a yellow elastic layer.

Action.—It draws the shoulder upwards and forwards.

2. Angularis Scapulæ (Levator Anguli Scapulæ) (Figs. 159, 4; 162, 3).

Synonyms.—Trachelo-subscapularis—*Girard.* Portion of the serratus magnus—*Bourgelat.* Elevator of the scapula—*Cuvier.* (Anterior portion of the *serratus magnus* of Percivall. The *levator anguli scapulæ* of Man.)

Situation—Form—Structure.—This is a very strong muscle, situated in front of the shoulder, triangular, flattened on both sides, thin at its superior border, thick behind and below, and almost entirely fleshy.

Attachments.—It takes its origin from the transverse processes of the five last cervical vertebræ by five distinct portions, which are directed towards the scapula in converging towards each other, and soon join to form a single muscular body, which is inserted into the internal face of the scapula, on its anterior triangular surface.

Relations.—This muscle is confounded at its inferior border with the serratus magnus. It is covered by the cervical trapezius, the mastoido-humeralis, and the small pectoral muscle. It covers the splenius, the inferior branch of the latissimus dorsi, and transversalis costarum. Near its junction with the serratus magnus, its internal face adheres very closely to the transverse processes of the three first dorsal vertebræ.

Action.—It draws forward the superior extremity of the scapula, while the humeral angle is carried backwards. If the shoulder becomes the fixed point, it can act in the extension or lateral inclination of the neck.

3. Splenius (Figs. 162, 4, 5; 163, 10).

Synonyms.—Cervico-trachelian—*Girard.*

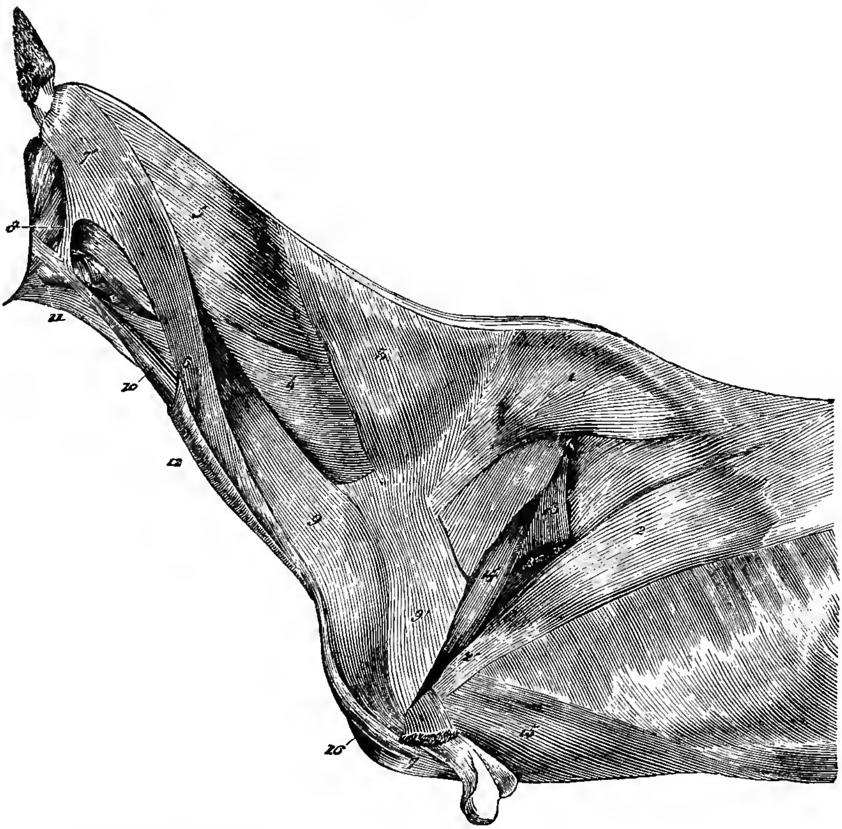
Form—Situation.—A considerable muscle, flattened on both sides, triangular, and comprised between the cord of the cervical ligament, the inferior branch of the latissimus dorsi, and the transverse processes of the four first cervical ribs.

Structure.—The splenius, aponeurotic only at its periphery, is composed of thick fleshy fasciculi which are all directed forwards and upwards, to reach the head and the first cervical vertebræ.

Attachments.—It is fixed, by its posterior border, to the lip of the cervical ligament and the summits of the spinous processes of the first dorsal vertebræ, by means of an aponeurosis which is continuous behind with that of the serratus anticus, and confounded, by its inner surface, with that of the complexus. Its anterior border is cut into four or five digitations, which constitute the movable insertions of the muscle. The superior digitation is the widest and thinnest, and terminates in an aponeurosis (Fig. 162, 5), which unites it to the mastoid tendon of the trachelo-mastoideus, and passes to the mastoid crest. The second joins a very strong tendon common to the splenius, the trachelo-mastoideus, and the mastoido-humeralis, which tendon is attached to the transverse process of the atlas (Fig. 162, 9). The two or three others are directly inserted into the transverse processes of the third, fourth, and fifth cervical vertebræ.

Relations.—The splenius is related, outwardly, to the rhomboideus, the

Fig. 159.



SUPERFICIAL MUSCLES OF THE NECK AND SPINAL REGION OF THE BACK AND LOINS.

1, Dorsal trapezius; 2, longissimus dorsi; 3, cervical trapezius; 4, angularis scapulæ; 5, splenius; 6, anterior, or superficial portion of the mastoido-humeralis; 7, its humeral insertion; 7′, its mastoid insertion; 8, the thin aponeurosis uniting this insertion to the sterno-maxillaris; 8′, posterior portion of the mastoido-humeralis; 9, its inferior aponeurosis inserted into the interstice of the long abductor of the arm; 10, sterno-maxillaris; 11, subscapulo-hyoideus; 12, portion of the cervical panniculus; 13, portion of the great extensor of the forearm; 14, posterior belly of the long abductor of the arm; 15, great pectoral muscle.

angularis scapulæ, cervical trapezius, and mastoido-humeralis; inwardly, to the complexus and the two oblique muscles of the head; by its inferior border, to the superior margin of the inferior branch of the longissimus dorsi.

Action.—It extends the head and neck in inclining them to one side. If the two act in concert, the extension is direct.

Third Layer.

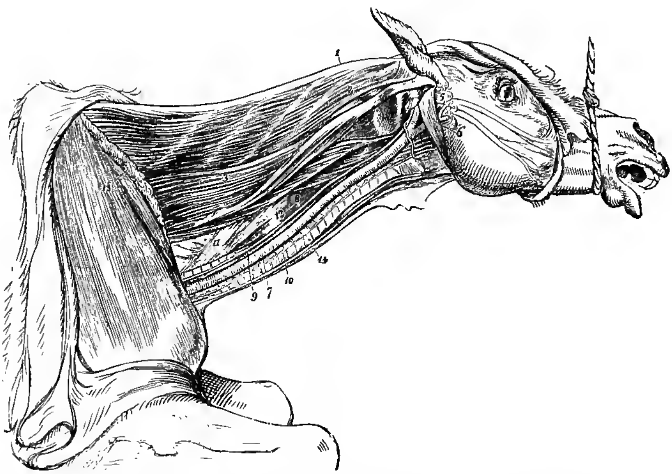
4. Complexus (Complexus Major) (Fig. 163, 6, 7).

Synonyms.—Dorso-occipitalis—*Girard.*

Situation—Direction—Form.—A powerful muscle, included between the internal surface of the splenius and the cervical ligament, the oblique direction of which, forwards and upwards, it follows; it is triangular, flattened on both sides, elongated from before to behind, and divided longitudinally into two unequal portions—a posterior and anterior.

Structure.—The posterior portion (Fig. 163, 6), the most considerable, is aponeurotic at its origin, intersected by linear fibrous bands which obliquely cross its direction, and is formed of fleshy fibres directed forwards. Those which compose the anterior portion (Fig. 164, 7), intermixed with some tendinous

Fig. 160.



LATERAL VIEW OF THE NECK (MIDDLE LAYER OF MUSCLES).

1, Funicular portion of the cervical ligament; 2, complexus major; 3, complexus minor; 4, rectus capitis posticus major; 5, rectus capitis posticus minor; 6, stylo-maxillaris; 7, carotid artery; 8, pneumogastric nerve and branch of sympathetic; 9, longus colli; 10, recurrent nerve; 11, inferior scalenus; 12, intertransversalis colli; 13, incision through rhomboideus and trapezius; 14, trachea.

fasciculi, are directed upwards, and appear to be inserted into the preceding. It is this difference in the direction of the fibres of the two portions of the complexus which allows them to be distinguished from one another; the two being only really separated by an interstice near their inferior extremity. Superiorly, the muscle is constricted to form the summit of the elongated triangle it represents, and terminates by a strong tendon.

Fixed insertions.—The posterior portion derives its origin: 1. From the summit of the spinous processes of the first dorsal vertebræ, by a strong aponeurosis which is confounded with that of the splenius and the serratus anticus. 2. From the transverse processes of the four or five dorsal vertebræ which follow the second, by as many aponeurotic digitations united by their margins. The anterior portion is fixed: 1. To the transverse processes of the two first dorsal vertebræ, by two tendinous digitations analogous to those of the posterior portion. 2. To the articular tubercles of the cervical vertebræ, by the inferior extremity of its fleshy fasciculi.

Movable insertion.—The movable insertion of the great complexus is effected through its superior tendon, which is fixed to the posterior face of the occipital protuberance, beside the cervical tuberosity.

Relations.—It is covered by the splenius and the trachelo-mastoideus. It covers the cervical ligament, the upper branch of the longissimus dorsi, the semi-spinalis colli, and the oblique and posterior straight muscles of the head. The aponeurotic digitations which attach it to the dorsal transverse processes, are comprised between the two branches of the longissimus dorsi. The interstice which separates, inferiorly, the two portions of the muscle affords a passage to the superior cervical artery.

Action.—It is a powerful extensor of the head.

5. Trachelo-Mastoideus (Complexus Minor) (Figs. 162, 6, 7 ; 163, 8, 9).

Synonyms.—Dorso-mastoideus—*Girard.* (*Trachelo-mastoideus—Percivall.*)

Situation—Direction.—Situated at the internal face of the splenius, in an oblique direction upwards and forwards, this muscle lies along the anterior border of the complexus, and follows the inferior branch of the longissimus dorsi, which it appears to continue to the head.

Form—Structure.—This is a long muscle, divided into two fleshy, fusiform, and parallel portions—anterior and posterior—which we might strictly consider as two distinct muscles. Both are composed of successive fasciculi, which become longer as they are superficial, and terminate by a tendon at their superior extremity. The tendon of the posterior muscle is flattened, and joins the mastoid aponeurosis of the splenius. That of the anterior muscle is funicular, and receives, before its insertion, a digitation from the splenius (Fig. 163, 10), and another from the mastoido-humeralis (Fig. 163, 11).

Fixed attachments.—The two fleshy portions have their fixed insertion in common with the anterior portion of the great complexus : 1. On the transverse processes of the two first dorsal vertebræ, through the medium of aponeurotic digitations which serve as an origin to the last-named muscle. 2. On the articular tubercles of the cervical vertebræ, by the inferior extremity of their component fasciculi.

Movable attachments.—The terminal tendon of the posterior muscle passes to the mastoid process of the temporal bone. The anterior passes to the transverse process of the atlas.

Relations.—Outwardly, with the splenius ; inwardly, with the complexus and the oblique muscles of the head. The tendon of the posterior fleshy portion is covered by the mastoid aponeurosis of the mastoido-humeralis.

Action.—The trachelo-mastoideus inclines to its side the head and upper part of the neck. It also acts as an extensor of the head.[1]

[1] Bourgelat has described, by the name of *long transversal*, the anterior portion of this muscle, and attached it to the posterior portion of the splenius. We do not know where to find one or other of these in the crude description of Lafosse and Vitet. Girard considered them, like ourselves, as a single muscle, which he designates the *dorso-mastoideus*. Rigot has united them with the anterior portion of the great complexus and the foremost fasciculi of the short transverse muscle (inferior branch of the longissimus dorsi), to make his *long transversal;* in doing so he has only complicated their description. These two muscular fasciculi being, to our view, exactly represented, the posterior, at least, by the *complexus minor* of anthropotomists,

Fourth Layer.

6. Spinalis or Semispinalis Colli (Fig. 161, 4).

Synonyms.—Short spinous—*Bourgelat.* Dorso-spinalis—*Girard.* (*Spinalis colli—Percivall. Transversalis colli* of Man.)

Situation.—Between the complexus and the cervical ligament, on the laminæ of the last five vertebræ of the neck.

Form—Structure—Attachments.—This muscle, a continuation in the cervical region of that of the back and loins, is generally formed of five thick and short fasciculi, strongly aponeurotic, directed forwards, upwards, and inwards.

These fasciculi, attached by their posterior extremities—*fixed insertion*—to the five last articular tubercles of the cervical region, are fixed by their anterior or superior extremities—*movable insertion*—into the sixth, fifth, fourth, third, and second spinous processes of that region.

Relations.—Outwards, with the complexus ; inwards, with the superior branch of the longissimus dorsi and the cervical ligament. By its anterior face, with the laminæ of the cervical vertebræ and the interlamellar ligaments.

Action.—An extensor and flexor of the cervical spine.

7. Intertransversales Colli (Fig. 162, 9).

Synonyms.—Intercervicals—*Girard.* (The *intertransversales* of Man. Not mentioned by Percivall.)

These are six small, short, and very tendinous fasciculi, each of which is doubled into two secondary fasciculi, a superior and inferior. They are lodged in the lateral excavations comprised within the transverse and articular processes of the cervical vertebræ, and are carried from one vertebra to another, except from the first to the second. Covered by the cervical attachments of the majority of the muscles of the neck, they cover the vertebræ to which they are attached, as well as the vertebral arteries and veins, and the intervertebral foramina. They incline the neck to the side.

8. Obliquus Capitis ~~Anticus~~ Posticus. or Inferioris (Fig. 161, 7).

Synonym.—Axoido-atloideus—*Girard.*

Form—Direction—Situation.—A short, thick, and broad muscle, oblique forwards and outwardly, and applied to the superior face of the two first vertebræ of the neck.

Structure and Attachments.—Its fibres are nearly all fleshy, parallel to each other, and longer as they become superficial ; they are attached by their posterior extremity—*fixed insertion*—to the external face of the spinous process of the axis, and by their anterior extremity—*movable insertion*—to the superior surface of the transverse process of the atlas.

Relations.—Outwards, with the splenius, the complexus and trachelo-mastoideus ; inwards, with the atlas, the axis, and the atlo-axoid articulation ; above, with the posterior straight muscles of the head ; below, with the anterior great straight muscle.

we have thought it proper to give it that name. With regard to the muscle generally termed the *complexus minor* by veterinary anatomists, following the example of Meckel we will describe it as a portion of the *rectus capitis anticus major*.

(Percivall names Girard's *axoido-occipitalis longus* the "complexus minor," and his *dorso-mastoideus* the "trachelo-mastoideus." Leyh, following Girard, designates the latter muscle the *dorso-mastoideus*.)

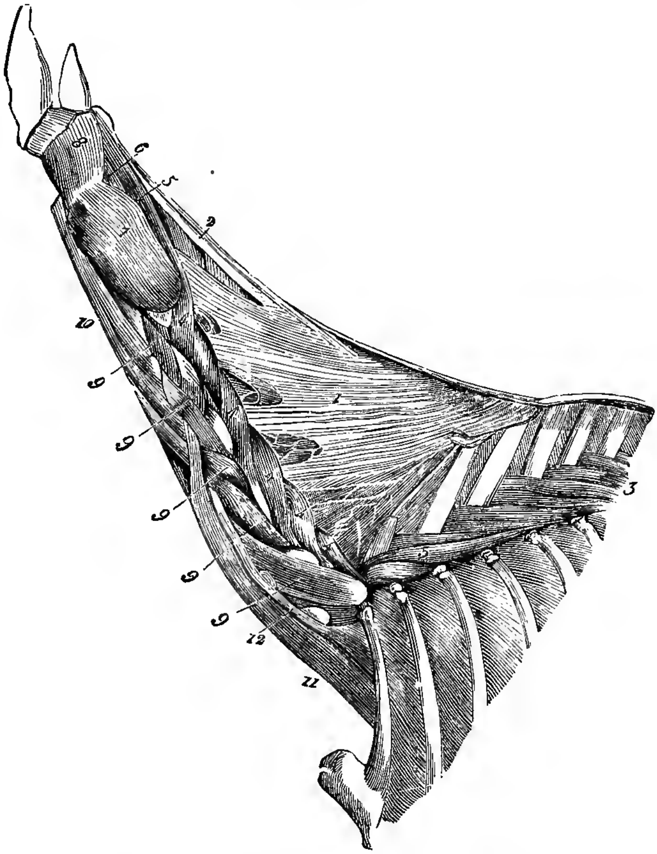
Action.—It pivots the atlas on the odontoid process of the axis; it is, therefore, the special rotator of the head.

9. Small Oblique, Obliquus Capitis ~~Posticus~~ Anticus. or Superioris (Fig. 161, 8).

Synonyms.—Atloido-mastoideus—*Girard.* (*Obliquus capitis superior—Percivall. Lateral atloido-occipitalis* of Leyh. *Obliquus superior* of Man.)

A short, thick, quadrilateral, and strongly aponeurotic muscle. Its fibres are fixed posteriorly—*origin*—to the lip bordering the transverse process of the atlas;

Fig. 161.



CERVICAL LIGAMENT AND DEEP MUSCLES OF THE NECK.

1, Lamellar portion of the cervical ligament; 2, funicular portion; 3, 3, semispinales muscles of the back aud loins; 4, 4, spinales colli; 5, rectus capitis posticus major; 6, small ditto; 7, great or inferior oblique muscle of the head; 8, small ditto; 9, 9, intertransversales colli; 10, anterior great straight muscle of the head; 11, inferior portion of scalenus muscle; 12, superior ditto.

they are carried from thence forward, upward, and inward, to be attached—*termination*—1. To the styloid process of the occipital bones. 2. To the external surface of that bone, on the imprints which border the mastoid crest posteriorly. 3. To the mastoid crest itself. This muscle is covered by the mastoid tendon of the trachelo-mastoideus, by the superior aponeurosis of the splenius, and that of the mastoido-humeralis. It covers the occipito-atloid articulation, the occipital insertion of the posterior straight muscles of the head, and the origin of the occipito-styloid and digastric muscles. It inclines the head on the atlas, and slightly extends it.

10. Posterior Great Straight Muscle of the Head (Rectus Capitis Posticus Major) (Fig. 161, 5).

Synonyms.—Small complexus and great posterior straight muscle—*Bourgelat.* Long and short axoido-occipitalis—*Girard.* (*Complexus minor* and *rectus capitis posticus major.*—*Percivall.* Leyh gives this muscle the same designation as Girard. It is the *rectus capitis posticus major* and *medius* of Man.)

Form—Structure—Situation.—Elongated, prismatic, easily divisible into two fasciculi—one superficial, the *complexus minor* of Bourgelat (and Percivall); the other deep, the *great posterior straight* muscle of Bourgelat (and the *rectus capitis posticus major* of Percivall)—entirely fleshy, and formed of parallel fibres, this muscle is lodged, with the small posterior straight muscle, in a triangular space circumscribed by the cord of the cervical ligament and the internal border of the oblique muscles.

Attachments.—It is attached, by its superior extremity, to the whole extent of the uneven lip which terminates the spinous process of the axis—*fixed insertion.* Its anterior extremity is insinuated beneath the small oblique muscle, and is fixed to the occipital bone, behind the superior insertion of the great complexus, the tendon of which receives some of the fibres of the superficial fasciculus—*movable insertion.*

Relations.—Above, with the complexus; below, with the small straight muscle; inwards, with the cord of the cervical ligament and the analogous muscle of the opposite side; outwards, with the oblique muscles.

Action.—This muscle, a congener of the complexus, aids in extending the head.

11. Posterior Small Straight Muscle (Rectus Capitis Posticus Minor) (Fig. 161, 6).

Synonyms.—Atloido-occipitalis—*Girard.* (*Rectus capitis posticus minor—Percivall.* The *Atloido-occipitalis superior* of Leyh. *The rectus capitis posticus minor* of Man.)

A very small, wide, and triangular muscle, flat above and below, and lying immediately upon the fibrous capsule of the occipito-atloid articulation. It is attached, posteriorly, to the superior face of the atlas—*origin;* in front, to the external surface of the occipital bone, below the preceding muscle, the action of which it shares.

Differential Characters in the Muscles of the Cervical Region in the other Animals.

1. **Ruminants.**—In the *Ox*, the *angularis scapulæ* arises by six digitations from all the cervical vertebræ except the first; the *splenius* is little developed, and is not attached to either the third or fourth cervical vertebra.

In the *Camel*, the angularis scapulæ is very small, and does not go beyond the fifth cervical vertebra in front. All the other muscles in this region are very much reduced in size. "If the splenius exists in the *Camel*, it is so small that it often escapes dissection" (Cuvier).

2. **Pig.**—The muscles of the superior cervical region in this animal are generally very developed. The *rhomboideus* is divided into two fleshy bodies, one of which proceeds to the occipital protuberance, and the other to the rudimentary cervical ligament and the first dorsal vertebræ. The *angularis* is attached, as in Ruminants, to the six cervical vertebræ; sometimes it even shows a digitation that descends to the atlas. The *splenius* only terminates anteriorly

by three fleshy portions; but they are voluminous, and are inserted, one into the atlas, another into the mastoid crest, and the third into the occipital protuberance. In the *complexus*, the two portions are completely separated from each other, except at their upper extremity, by the interspace lodging the superior cervical artery. The aponeurosis attaching the muscle to the spinous processes of the first dorsal vertebræ is not confounded with that of the splenius or the serratus anticus respiratory muscle. The atloidean fleshy body of the *trachelo-mastoideus* is scarcely distinct from the superior branch of the longissimmo dorsi and the intertransversales. Lastly, it is difficult to distinguish the *small posterior straight* muscle from the deep fasciculus of the *great straight muscle*.

3. **Carnivora.**—In these animals the muscles of the superior cervical region are nearly all voluminous, as in the Pig. The *rhomboïdeus* is bifid at its origin, and its anterior branch arises from the mastoid crest. The *angularis* is also attached to the last six cervical vertebræ. Very thick and broad, the *splenius* only passes to the atlas and mastoid crest. The *oblique* and *straight posterior muscles of the head* are also remarkably thick.

B. Inferior Cervical or Trachelian Region.

The muscles composing this region are situated in front of the cervical vertebræ, and are, for the most part, grouped around the trachea, which they envelop as in a kind of sheath. They are eleven in number, and are: the *cervical panniculus*, *mastoido-humeralis*, *sterno-maxillaris*, *sterno-thyro-hyoideus*, *subscapulo-hyoideus*, *rectus capitis anticus major*, *rectus capitis anticus minor*, *rectus capitis lateralis*, *scalenus*, and the *longus colli*.

Preparation.—1. Place the animal in the first position. 2. Remove the skin of this region, in order to expose and study the cervical panniculus. 3. Remove that muscle and the parotid gland to prepare the mastoido-humeralis,[1] the stylo-maxillaris, and sterno-thyro-hyoideus. 4. Transversely cut through the mastoido-humeralis near the angle of the shoulder, and isolate it from the subscapulo-hyoideus to expose this muscle; taking care to preserve the jugular vein and parotid gland, in order to study their relations with it. 5. Remove the fore limbs; open the thoracic cavity by sawing through the eight first ribs near their superior extremity; take out the viscera contained in this cavity, as well as the trachea, œsophagus, pharynx, and larynx, to expose the longus colli, the scalenus, and the straight muscles of the head.

1. Subcutaneous Muscle of the Neck (Cervical Panniculus) (Figs. 159, 12; 17?, 1).

Synonyms.—It has been described by Bourgelat, and the majority of veterinary anatomists who have followed him, as two muscles: the cuticularis of the neck and the face. (Percivall includes this muscle in his description of the *panniculus carnosus*. It is the *platysma myoides* of Man.)

This is a membraniform expansion, partly fleshy, partly aponeurotic, which covers the muscles of the neck, the submaxillary space, and the face.

The fleshy fibres form, in front of the neck, a thin band, which is united, through the medium of a fibrous raphé, to that of the opposite side. This band is in contact with the sterno-maxillaris, sterno-thyro-hyoideus, and subscapulo-hyoideus, as well as the jugular vein—enveloping them all as in a sort of furrow. It gradually becomes thinner from below upwards, in such a manner that around the upper part of the throat it is only composed of some scattered fibres. In the submaxillary space, and on the expanding borders of the inferior maxilla, the fleshy fibres appear again of a certain thickness, but only to become attenuated on the external surface of the cheeks.

These fleshy fibres leave the cariniform cartilage of the sternum[2] and inter-

[1] The mastoido-humeralis may be dissected at the same time as the trapezius, the subject being placed in the second position. This conveniently permits the superior insertions of the muscle to be studied (see Fig. 159).

[2] It will be seen, on referring to Fig 159 and its legend, that we restore to the cervical

mediate middle raphé of the two muscles, and, directing their course outwards and upwards, soon become confounded with the aponeurosis. The latter, extremely thin, is spread over the mastoido-humeralis, the superior cervical muscles, the parotid region, and the cheeks, and is finally attached to the zygomatic crest. On arriving near the commissure of the lips, it is united to the buccinator muscle by a fleshy fasciculus named, in Man, the *risorius Santorini* (Fig. 163).

The cervical panniculus braces the muscles it covers, during their contraction, and pulls backwards the commissures of the lips. We doubt very much whether it has—in the cervical region at least—any action on the skin, for it adheres but very slightly to its inner surface.

2. Mastoido-humeralis (Levator Humeri) (Figs. 158, 160, 162, 163).

Synonyms.—The muscle common to the arm, neck, and head—*Bourgelat.* Representing the cleido-mastoid, and the clavicular portions of the trapezius and deltoid of Man, and the trachelo-acromialis peculiar to quadruped Mammals[1]—*G. Cuvier, Leçons d'Anatomie Comparée*, 2nd edition. (This is the muscle which Percivall names the *levator humeri.* The above is the designation given to it by Girard and Chauveau. Leyh gives it the same designation as Bourgelat.)

Extent—Situation—Direction—Composition.—This muscle extends from the summit of the head to the inferior part of the arm, and is applied to the scapulo-humeral angle at the side of the neck, in an oblique direction downwards and backwards. It is composed of two portions lying longitudinally, and somewhat intimately united, and distinguished into *anterior* and *posterior*.

Form—Structure—Attachments.—A. The *anterior* or *superficial* portion (Fig. 159, 6) constitutes a long fleshy band, which appears to be united, by its anterior border, to the cuticular muscle of the neck. Its superior extremity, thin and wide, is attached to the mastoid process and crest by an aponeurosis (Fig. 159, 71), which is united, in front, to the tendon of the sterno-maxillaris by a very thin cellulo-aponeurotic fascia. Its inferior extremity, thicker than the superior, is inserted by means of a very short aponeurosis into the humerus, on the salient border descending from the deltoid imprint, and which limits, in front, the musculo-spiral groove on the body of that bone (Fig. 159, 7).

panniculus the sternal band attributed until now to the mastoido-humeralis. These are the considerations which induce us to make this modification: 1. This band is not distinct from the cervical panniculus; a separation between the two muscles can only be artificially obtained. 2. In dissecting this band with care, we can see that its fibres, like those of the panniculus, are not mixed with those of the mastoido-humeralis (superficial portion); they pass along the external surface of that muscle, to which they intimately adhere, it is true, but they can easily be separated, and are continuous with the aponeurosis of the first.

[1] At first sight, we might hesitate to admit that this muscle is formed of such varied and complicated elements as are enumerated above. Nevertheless, it is a scientific fact; and we will give a demonstration, as simple as it is clear, that such is the case—the idea we owe to J. F. Meckel. If we take the Dog, for example, and suppose it to be possessed of a clavicle extending from the anterior extremity of the sternum to the acromion, this clavicle would bisect, transversely, the inferior portion of the mastoido-humeralis, which would thus be divided into two portions—a superior and an inferior. The first, extending from the clavicle to the mastoid process, on this side, and on the other to the mastoid crest, as well as to the cervical ligament, where it is confounded with the trapezius, would exactly represent the *clavicular portion* of the latter muscle, and the *cleido-mastoideus.* With respect to the inferior portion, it perfectly resembles, by its attachments, the *clavicular portion* of the deltoid. But, on the contrary, if we suppose Man deprived of a clavicle, the three muscular fasciculi indicated, in becoming confounded with each other, would form the mastoido-humeralis of the Dog, *minus* the posterior portion, or the trachelo-acromialis, which is not represented in Man.

B. The *posterior* or *deep portion* (Fig. 159, 9) is a second muscular band, shorter and stronger than the preceding. It is attached, above, to the transverse processes of the first four cervical vertebræ by as many fleshy bands (Fig. 159, 8), which cover the superficial portion. The upper digitation, given off to the atlas, is united to the tendon common to the trachelo-mastoideus and splenius (Figs. 162, 9; 163, 9, 10, 11). The inferior extremity of this portion of the muscle widens on the scapulo-humeral angle, which it envelops in becoming closely united to the anterior portion, terminating with it on the humerus. An aponeurosis, which is confounded with that of the trapezius, and sends off a septum into the interstice between the two portions of the long abductor of the arm, concurs to fix this extremity by spreading over the muscles of the arm.

Relations.—It is covered, near its mastoid insertion, by the parotid gland and the cervico-auricularis muscles; for the remainder of its extent, by the aponeurosis of the cervical panniculus, from which it is separated by a thin fascia continuous with that which extends over the trapezius. It covers the splenius, trachelo-mastoideus, oblique muscles of the head, subscapulo-hyoideus (to which it adheres intimately), the digastricus, long flexor of the head, the angularis, scalenus, small pectoral, supra- and infra-spinatus muscles, the long abductor of the arm, and the coraco-radialis.

Action.—When the superior is the fixed point, it carries the entire anterior limb forward. This muscle, therefore, plays a very important part in locomotion, as it is called into action when the animal raises the fore limb in getting over the ground. If the fixed point of the muscle is the limb, it inclines the head and neck to one side.

3. Sterno-maxillaris (Figs. 159, 10; 174, 4).

Synonym.—The *sterno-mastoideus* of Man.

Form—Structure—Situation—Direction—Attachments.—A long narrow muscle, almost entirely fleshy, and terminated at its upper extremity by a flattened tendon; situated in front of the neck, beneath the panniculus, and parallel to the anterior border of the superficial portion of the mastoido-humeralis, from which it is separated by a space that lodges the jugular vein; attached, inferiorly, to the cariniform cartilage of the sternum—*fixed insertion;* and superiorly—*movable insertion*—to the curved portion of the posterior border of the maxillary bone by its terminal tendon.

Relations.—The muscle is covered by the panniculus, and the parotid gland. It covers the trachea, the subscapulo-hyoideus, sterno-thyro-hyoideus, and the maxillary gland. Its external border, parallel to the anterior border of the mastoido-humeralis, forms with it a longitudinal depression termed the *jugular furrow*, because it lodges the vein of that name. Its inner border is intimately united, in its lower third, to that of the opposite muscle.

Action.—It directly flexes the head, when acting in concert with its congener; but alone it turns it to one side. Lafosse and Rigot have wrongly considered this muscle as a depressor of the lower jaw. Bourgelat has correctly stated that it cannot move this jaw independently. (Percivall says that the pair will assist in opening the mouth; and Leyh asserts that when the mouth is closed, each muscle will act as a flexor to the head.)

4. Sterno-thyro-hyoideus (Fig. 174, 6, 7).

Form—Structure—Situation—Attachments.—Small, ribbon-shaped, long, and slender muscle in two portions; digastric; situated in front of the trachea; confounded at their inferior extremity and united to those of the opposite side, so as to form a single fasciculus which is attached to the cariniform cartilage of the sternum—*fixed insertion;* isolated from each other above the tendon which makes them digastric, and terminating by their superior extremity—*movable insertion:* the first, on the inferior surface of the body of the hyoid bone in common with the subscapulo-hyoideus; the second, on the posterior border of the thyroid cartilage.

Relations.—Covered by the sterno-maxillaris and the panniculus muscle, they cover the anterior face of the trachea.

Action.—Depressors of the hyoid bone and larynx.

5. Subscapulo-hyoideus (Figs. 159, 11; 174, 5).

Synonyms.—Hyoideus—*Bourgelat.* (*Subscapulo-hyoideus—Percivall.*)

Form—Structure—Situation—Direction.—This muscle forms a thin and wide band, almost entirely fleshy, oblique forwards and upwards, extending from the scapulo-humeral angle to the submaxillary space, and applied to the side of the trachea, which it slightly crosses.

Attachments.—It derives its fixed insertion from the inner surface of the subscapularis, by an aponeurosis which is detached from that covering the latter muscle. Its movable insertion is into the body of the hyoid bone, in becoming confounded with the sterno-thyro-hyoideus, and in being intimately united to the muscles of the opposite side.

Relations.—Outwardly, with the subscapularis, supra-spinatus, small pectoral, mastoido-humeralis—which closely adheres to it, the jugular vein, the sterno-maxillaris, and the panniculus. Inwardly, with the scalenus, the large anterior straight muscle of the head, the main trunk of the carotid artery and the nerves accompanying it, the trachea, thyroid gland, and the inferior face of the larynx. The jugular vein is entirely separated from the carotid artery by this muscle in the upper half of the neck.

Action.—It is a depressor of the hyoid bone and its appendages.

6. Great Anterior Straight Muscle of the Head (Rectus Capitis Anticus Major) (Figs. 161 and 162, 10; 163, 13).

Synonyms.—Long flexor of the head—*Bourgelat.* Trachelo-suboccipitalis—*Girard.* (*Rectus capitis anticus major—Percivall. Trachelo-occipitalis—Leyh.*)

Form—Structure—Situation—Direction.—A long, flat muscle, fasciculated in its posterior half, terminated in a tendinous cone at its anterior extremity, and passing along the first cervical vertebræ in front.

Attachments.—Behind, to the transverse processes of the third, fourth, and fifth cervical vertebræ by as many fleshy digitations, the most inferior of which are the longest—*fixed insertion.* In front, into the imprints on the body of the sphenoid bone and the basilar process, by its terminal tendon—*movable insertion.*

Relations.—Outwardly, with the mastoido-humeralis, the subscapulo-hyoideus, and the small anterior straight muscle. Inwardly, with the longus colli and the muscle of the opposite side. In front, with the common carotid, the nerves accompanying this artery, and the guttural pouch, which lines it near its movable insertion. Behind, with the great oblique muscle of the head and the occipito-atloid articulation.

Action.—It either directly flexes the head or carries it to one side, according as it acts alone or with its fellow of the opposite side.

7. Small Anterior Straight Muscle of the Head (Rectus Capitis Anticus Minor).

Synonyms.—Flexor capitis brevis—*Bourgelat.* Atloido-suboccipitalis—*Girard.* (*Rectus capitis anticus minor—Percivall. Atloido-occipitalis inferior—Leyh.*)

A small, entirely fleshy, prismatic fasciculus, lying to the external side of the preceding muscle; attached, posteriorly, to the inferior face of the body of the atlas; in front, to the body of the sphenoid bone and the basilar process, beside the great anterior straight muscle. It is covered by the guttural pouch, and covers the occipito-atloid articulation. It concurs in flexing the head.

8. Small Lateral Straight Muscle (Rectus Capitis Lateralis).

Synonyms.—Flexor capitis parvus—*Bourgelat.* Atloido-styloideus—*Girard.* (*Obliquus capitis anticus—Percivall.* The *rectus capitis lateralis* of Man.)

Smaller than the preceding, and prismatic and entirely fleshy, like it, this muscle lies on the side of the occipito-atloid articulation; it is attached to the atlas, outside the small anterior straight muscle—*fixed insertion;* and to the inner face of the styloid process of the occipital bone—*movable insertion.* It is the congener of the two anterior straight muscles of the head.

9. Scalenus (Figs. 161, 162, 163).

Synonyms.—Costo-tracheleus—*Girard.* (*Scalenus anticus* and *posticus* of Man.)

Situation—Direction—Composition.—Deeply situated at the inferior part of the neck, in an oblique direction downwards and backwards, this muscle comprises two portions of unequal dimensions, placed one above another.

Form—Structure—Attachments.—A The *superior portion* (*scalenus posticus* of Man), the smallest, is composed of three or four fleshy fasciculi, attached by their extremities to the transverse processes of the last three or four cervical vertebræ. The last terminates at the superior extremity of the first rib.

B. The *inferior* (*scalenus anticus* of Man), the most considerable, is flattened on both sides, thick and wide posteriorly, thin and narrow anteriorly, and is composed almost entirely of fleshy fibres which are longest as they are inferior. It is attached: 1. To the transverse processes of the last four cervical vertebræ by short fasciculi scarcely distinct from one another, the first of which is crossed by the last digitation of the great anterior straight muscle. 2. To the anterior border and external face of the first rib, where all its fibres end.

Relations.—The scalenus responds: by its external face, to the subscapulo-hyoideus, mastoido-humeralis, and the deep pectoral; by its internal face, to the longus colli, trachea, common carotid artery and its accompanying nerves, and—on the left side only—to the œsophagus; by its inferior border, to the jugular vein. The two portions of the scalenus are separated from each other, in front of the first rib, by an interspace traversed by the nerves of the brachial plexus.

Action.—When the first rib is the fixed point, this muscle either directly flexes the neck or inclines it to one side. When the neck is the fixed point, it draws forward the first rib and fixes it in this position during the dilatation of the chest, in order to aid the inspiratory action of the external intercostal muscles.

10. Long Muscle of the Neck (Longus Colli).

Synonyms.—Flexor longus colli—*Bourgelat.* Subdorso-atloideus—*Girard.* (*Longus colli — Percivall. Dorso-atloideus—Leyh.*)

Situation—Composition.—A single and considerable muscle, immediately covering the inferior aspect of all the cervical and the first six dorsal vertebræ, and composed of two lateral portions which are united on the median line, and constitute, in certain animals, two distinct muscles.

Structure—Attachments.—Each lateral portion of the longus colli is composed of a succession of very tendinous fasciculi. The most posterior of these is attached to the inferior face of the bodies of the first six dorsal vertebræ, and proceeds directly forward to reach the inferior tubercle of the sixth cervical vertebra, into which it is inserted by a strong tendon. The other fasciculi, less considerable, and confounded outwardly with the intertransversales of the neck, are carried from one cervical vertebra to another, and are directed forwards, upwards, and inwards, converging towards those of the opposite side. They are attached successively: outwardly, to the transverse processes of the last six cervical vertebræ; inwardly, to the inferior ridge on the bodies of the first six. The most anterior fasciculus passes to the inferior tubercle of the atlas, into which it is inserted by a tendon common to it and the fasciculus of the opposite side, and which receives the most superficial fibres of the three or four preceding fasciculi.

Relations.—Above and behind, with the vertebræ which it covers, as well as their intervertebral discs; below and in front, with the trachea and œsophagus, and the vessels and nerves accompanying these two tubes; on the sides, with the great anterior straight and the scalenus muscles in its cervical portion; and in its intra-thoracic portion, with the pleuræ, and important vessels and nerves.

Action.—It flexes the whole neck, and the cervical vertebræ on one another.

Differential Characters in the Muscles of the Inferior Cervical Region in the other Animals.

A. Ruminants.—In the *Ox* and *Sheep*, the arrangement of the *cervical panniculus* offers a very considerable difference from that observed in Solipeds. The fleshy portion is absent, or appears to be absent, in the cervical region; the anterior muscles of the neck are only covered by a thin fascia developed on the sides of the neck. When this fascia reaches the face, it becomes continuous with the fleshy fibres; a fasciculus of these fibres comports itself as in the Horse, and joins the buccinator: another is intercrossed in the maxillary space by the analogous fasciculus of the opposite side.

The *cervical panniculus* in the *Ox* is also distinguished by an extremely remarkable peculiarity, which it is necessary to allude to here:—The fleshy cervical band, altogether absent in the Sheep, is not so in the Ox; we have found it forming, beneath the above-mentioned aponeurotic fascia, the long, thick strip which has been described by veterinary anatomists as the analogue of the sterno-maxillaris in the Horse. This strip is attached, like the muscular band which represents it in Solipeds, to the anterior point of the sternum. But its fibres, instead of being spread outwards over the mastoido-humeralis, ascend, perfectly isolated from that muscle, to the posterior border of the inferior maxilla. There it terminates (Fig. 172, 18) by a flattened tendon, which, after reaching the anterior border of the masseter, is confounded with the aponeurosis of that muscle, and sends some fibrous bands over the muscles of the face.

The two portions of the *mastoido-humeralis* of Ruminants are better defined, and more oblique on one another, than in the Horse. The *superficial portion* receives, on its inner face, a small, bright-red, funicular fasciculus, which proceeds from the cartilage of the first rib, and which Meckel is inclined to consider as the vestige of the subclavius. It is divided, superiorly, into two branches: one, the *clavicular portion of the trapezius*, very wide, passes to the mastoid process, the curved line of the occipital bone, and to the cervical ligament, in becoming confounded with the trapezium (Fig. 172, 22); the other, the *cleido-mastoideus*, terminates in a tendon that joins the sterno-maxillaris, and is inserted into the basilar process, after receiving the fibres of the long flexor of the head (Fig. 172, 21). The upper extremity of the *deep portion* of the mastoido-humeralis is inserted into the atlas by a flattened tendon alone, which is quite distinct from the atloid insertions of the splenius and the trachelo-mastoideus.

In the *Sheep* and *Goat*, the costal band that joins the superficial portion is absent. The latter is divided at its inferior extremity into two branches, between which pass the biceps. The upper branch passes to the epitrochlea.

The *sterno-maxillaris* muscle, instead of being inserted into the inferior maxilla, is united to the suboccipital branch of the mastoido-humeralis, to be attached to the basilar process. At another time we will discuss the determination of this muscle, and that of the fleshy band here considered as belonging to the first (*see* Spinal Nerve).

The *sterno-thyro-hyoid* muscle is thicker than in the Horse, and not digastric.

The *subscapulo-hyoideus* of Ruminants is but slightly developed, and might be termed the *trachelo-hyoideus*, as it proceeds to the transverse process of the third or fourth cervical vertebra. In its passage beneath the basilar branch of the mastoido-humeralis and sterno-maxillaris, it contracts adhesions with the fibres of these two muscles.

The *great anterior straight muscle of the head* descends to the sixth cervical vertebra. Its cervical insertions are covered by a very strong muscular fasciculus, which is annexed to it. Like it, this fasciculus leaves the sixth cervical vertebra, and is attached to the transverse processes of the four vertebræ preceding the last, by becoming confounded with the inter-transversales, and finally terminating at the tracheal process of the atlas by fleshy and aponeurotic fibres. This muscular fasciculus singularly strengthens the neck when it is inclined to one side. In consequence of its attachments, it might be named the *trachelo-atloideus* (Fig. 172, 24).

Lastly, in Ruminants the *superior scalenus* is very developed, being a flattened band which, gradually expanding, is prolonged to the surface of the serratus magnus.

B. **Pig.**—In this animal, the *cervical panniculus* is in two portions: an inferior, which comes from the point of the sternum; and a superior, from the external capsular region. They unite in front, and are prolonged in common on the muscles of the face, contracting adhesions with the outer surface of the body and branches of the inferior maxilla.

The other muscles of the inferior cervical region are not unlike those of Ruminants.

Of the two portions of the *mastoido-humeralis*, the superficial is bifid at its superior extremity. The posterior branch, the *clavicular portion of the trapezius*, is attached to the side of the occipital protuberance; the anterior branch, the *cleido-mastoideus*, goes beneath the external auditory hiatus, to the crest that replaces the mastoid process; the deep portion is attached above to the atlas only.

In the Pig, the *sterno-maxillaris* exactly represents that muscle in the Horse, as its tendon passes directly to the mastoid process.

The *sterno-thyro-hyoideus* is double; the supplementary branch going to the inferior face of the thyroideus.

The *subscapulo-hyoideus* and *great anterior straight muscle of the head*, resemble those of the Ox. The *small straight lateral* muscle is scarcely distinct from the small oblique. The *superior scalenus* extends to the third rib. The two lateral portions of the *longus colli* are separate, and form two distinct muscles.

C. **Carnivora.**—In the *Dog*, each *cervical panniculus* is in two portions, as in the Pig. The fibres from the breast are directed in a diverging manner over the face, the submaxillary space, and the parotid gland, where they form the parotido-auricularis muscle. The portion coming from the external scapular region is thicker and wider; it covers the lateral parts of the neck, the parotid gland, the parotido-auricularis, passes above the preceding, and terminates on the face and in the submaxillary space, where its fibres join those of the opposite side.

The *mastoido-humeralis* comports itself somewhat as in Ruminants and the Pig. The *superficial portion* is bifid superiorly; one of its branches is fixed into the mastoid process—the *cleido-mastoideus*; the other into the mastoid crest and cervical ligament, in uniting by aponeurosis with the trapezius—the *clavicular portion of the trapezius*. The deep portion passes from the atlas to the scapular spine.

The tendon of the *sterno-maxillaris* goes to the mastoid process. The *sterno-thyro-hyoideus* is thick and not digastric, and commences from the cartilage of the first rib.

The Carnivora have no *subscapulo-hyoideus*; but they possess a very long *scalenus*, which passes to the eighth rib, and a *longus colli*, which tends to become divided into two lateral portions.

Spinal Region of the Back and Loins.

This offers for study seven pairs of muscles, nearly all of which have their insertions extended over the dorso-lumbar spine, and are disposed in four layers on each side of this long multifidious crest. These muscles are—

IN THE FIRST LAYER.

Trapezius. Latissimus Dorsi.

IN THE SECOND LAYER.

Serratus Anticus. Serratus Posticus.

IN THE THIRD LAYER.

Longissimus Dorsi. Transversalis Costarum.

IN THE FOURTH LAYER.

Semispinalis of Back and Loins.

Preparation.—1. Place the animal in the second position. 2. Remove the skin with the panniculus and the mass of olecranian muscles, to show, in a first operation, the trapezius and latissimus dorsi (Fig. 159). 3. In a second operation, remove the entire fore limb, with the latissimus dorsi muscle, the mode of termination of which may then be studied; then prepare the two small serrated muscles. 4. Remove these two muscles, as well as the angularis of the scapula and the splenius, to expose the transversalis costarum and longissimus dorsi (Fig. 163). The superior branch of the latter remaining covered by the great complexus, excise this muscle, leaving only its insertions into the transverse processes of the dorsal vertebræ, to show how they are fixed between the two branches of the longissimus dorsi. 5. Dissect the semispinalis by removing the longissimus dorsi and the internal angle of the ilium.

First Layer.

1. TRAPEZIUS (Fig. 159, 1, 3).

Synonym.—Dorso- and cervico-acromialis—*Girard.*

Situation—Form—Structure.—This is a superficial membraneous muscle, situated on the sides of the neck and withers. Its shape is that of a triangle base upwards. It is aponeurotic at its upper border and in its centre, which allows it to be distinguished, especially in emaciated subjects, into a cervical and a dorsal portion. The fleshy fibres of the first are directed downwards and backwards; those of the second are oblique forwards.

Attachments.—By its superior aponeurosis, it is fixed to the cord of the cervical ligament and to the summits of the transverse processes of the first dorsal vertebræ, where it adheres to the external face of the latissimus dorsi. By its central aponeurosis and that of its summit, it is attached to the tuberosity of the olecranian spine and the external scapular aponeurosis.

Relations.—This muscle is covered by two aponeurotic planes, the fibres of which cross its own at a right angle. Inwardly, it responds to the rhomboideus, splenius, angularis, deep pectoral, the supra- and infra-spinatus, and the latissimus dorsi.

Action.—It raises the shoulder, and carries it forward or backward, according as one or other of its muscular portions contract.

2. GREAT DORSAL (LATISSIMUS DORSI) (Fig. 159, 2).

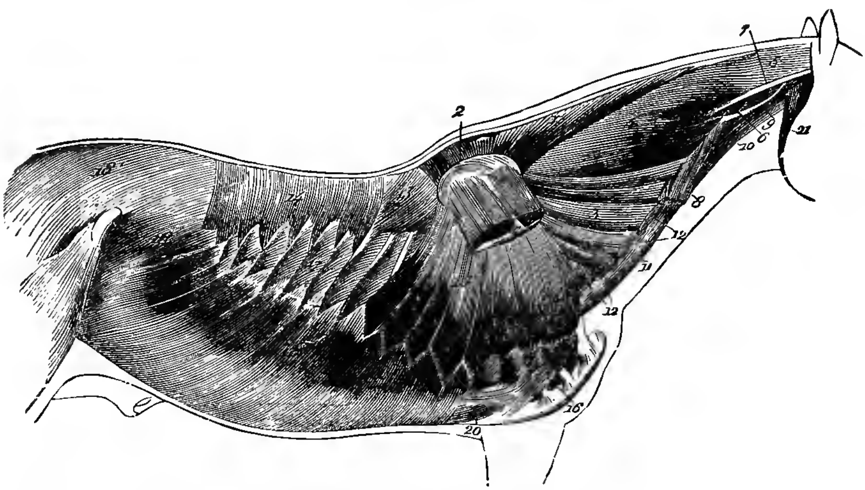
Synonyms.—Dorso-humeralis—*Girard.* (*Latissimus dorsi—Percivall.*)

Form—Situation—Structure—Attachments.—A very broad triangular muscle, extended over the loins, back, and side of the thorax, and formed of an aponeurotic and a muscular portion.

The aponeurosis is attached, by its superior border, to the summits of the spinous processes of all the lumbar, and the last fourteen or fifteen dorsal vertebræ—*fixed insertion of the muscle.*

The fibres of the fleshy portion are detached from the inferior border of the aponeurosis, at the twelfth or thirteenth ribs, to the cartilage of the scapula. They are directed forwards and downwards, and all converge into a flat tendon which is inserted into the internal tuberosity on the body of the humerus—*movable insertion.* This tendon is remarkable, at its termination, for being

Fig. 162.



MUSCLES OF THE SPINAL REGION OF THE NECK, BACK, AND LOINS (MIDDLE LAYER); AND OF THE COSTAL AND ABDOMINAL REGION (SUPERFICIAL LAYER).

1, 2, Rhomboideus; 3, angularis muscle of the scapula; 4, splenius; 5, its mastoid aponeurosis; 6, mastoid portion of the trachelo-mastoideus; 7, its tendon; 8, cervical insertions of the mastoido-humeralis; 9, atloidean tendon common to the mastoido-humeralis, splenius, and trachelo-mastoideus; 10, great anterior straight muscle of the head; 11, inferior scalenus; 12, superior scalenus; 13, small anterior serratus; 14, posterior ditto; 15, serratus magnus; 16, anterior fibres of the rectus abdominis, sometimes described as the *transversalis costarum;* 17, one of the external intercostals; 18, great oblique; 20, rectus abdominis; 21, stylo-maxillaris portion of the digastric muscle.

placed at the external face of the teres magnus or adductor of the arm, from which it receives fibres, and between it and the long extensor of the forearm; it then turns inwards, on the inferior extremity of the first, in such a manner that this extremity is comprised within a duplicature of the membranous tendon of the latissimus dorsi.

Relations.—This muscle is covered by the skin, panniculus carnosus, dorsal portion of the trapezius, and the mass of olecranian muscles. It covers the infra-spinatus; the cartilage of the scapula; the rhomboideus; the anterior and posterior serrated muscles, the aponeurosis of which is directly joined to its own; the longissimus dorsi; the principal gluteal; a portion of the external surface of the last ribs, to which its aponeurosis strongly adheres; as well as to the corresponding external intercostals, and the serratus magnus. Between the last rib and the external angle of the ilium, the aponeurosis unites with the small oblique, but more particularly with the great oblique, muscle of the abdomen ; it is prolonged, posteriorly, on the muscles of the croup to constitute the gluteal aponeurosis.

Action.—It carries the arm backwards and upwards ; and it may, according to a great number of authors, serve as an auxiliary in inspiration when its fixed point is the humerus. According to others, but in whose opinion we do not share, it is an expiratory muscle.

Second Layer.

3. Small Anterior Serrated Muscle (Serratus Anticus) (Fig. 162, 13).

Synonyms. — Dorso-costalis — *Girard.* Anterior portion of the long serrated muscle—*Bourgelat.* (*Superficialis costarum—Percivall. Anterior serrated muscle* of Leyh. *Serratus posticus superior* of Man.)

Form—Situation.—This is a flat, thin, quadrilateral muscle, situated beneath the rhomboideus and the latissimus dorsi.

Structure.—It is composed of an aponeurotic and a fleshy portion. The first is confounded, in front, with the aponeurosis of the splenius, and is insinuated, behind, underneath that of the posterior small serratus, with which it soon becomes united. Its inferior border gives origin to the muscular portion, a little above the interval which separates the transversalis costarum and the longissimus dorsi. Narrow and elongated antero-posteriorly, the muscular portion is composed of bright-red fibres directed obliquely backwards and downwards, which form at the inferior border irregular, and sometimes but faintly marked, festoons.

Attachments.—It takes its fixed insertion, by the superior border of its aponeurosis, from the summits of the anterior dorsal spines, with the exception of the first, to the thirteenth inclusive. The movable insertion takes place on the external surface and anterior border of the nine ribs succeeding the fourth, by means of the digitations of the fleshy portion. This muscle is also attached to the external surface of these ribs by a short fibrous band, which is detached from the internal face of the aponeurosis, near its inferior border, and penetrates the space between the longissimus dorsi and the transversalis costarum.

Relations.—Outwards, with the rhomboideus, serratus magnus, latissimus dorsi, and the posterior small serratus, which covers its three last festoons ; inwards, with the longissimus dorsi, the transversalis costarum, and the external intercostals.

Action.—This is an inspiratory muscle, and it also serves as a check to the deep spinal muscles.

4. Small Posterior Serrated Muscle (Serratus Posticus) (Fig. 162, 14).

Synonyms.—Lumbo-costalis—*Girard.* Posterior portion of the long serrated muscle—*Bourgelat.* (*Superficialis costarum—Percivall.* The *posterior serrated* muscle of Leyh. The *serratus posticus inferior* of Man.)

Situation.—Situated behind the preceding, which it follows, and presenting the same form and arrangement, this muscle also offers the following particular features for study :—

1. *Structure.*—Its muscular portion, which is thicker and of a deep-red colour, is cut into nine well-defined digitations.[1] The fibres which compose it run in an almost vertical direction.

[1] It frequently happens that only eight digitations are found in each muscle.

2. *Attachments.*—Its aponeurosis, closely united to that of the latissimus dorsi, which covers it, is attached to the spinous processes of the dorsal vertebræ succeeding the tenth, and to some lumbar vertebræ. Its digitations are fixed to the posterior border and external face of the nine last ribs.

3. *Relations.*—Outwards, with the latissimus dorsi; inwards, with the small anterior serratus, the longissimus dorsi, transversalis costarum, and the external intercostals. Some of its posterior digitations are partly concealed by those of the great oblique muscle of the abdomen; the last, indeed, is entirely covered by that muscle.

4. *Action.*—This is an expiratory muscle, in consequence of its drawing the ribs backwards and upwards.

Third Layer.

5. The Ilio-spinalis Muscle (Longissimus Dorsi) (Fig. 163).

Synonyms.—It represents the long dorsal, short transversal, and long spinous of Bourgelat. Cuvier and others have described it as consisting generally, in Mammalia, of five particular muscles, designated as longissimus dorsi, transversalis cervicis, semispinalis dorsi, and semi-spinalis colli. It corresponds to the longissimus dorsi, and transversalis cervicis of Man.

(Percivall designates this important muscle the *longissimus dorsi*—the name given to its analogue in Man. By Girard, Leyh, and Chauveau, it is styled the *ilio-spinalis*.)

Extent—Situation.—This, the most powerful and complex of all the muscles in the body, extends along the dorso-lumbar spine, above the costal arches, from the anterior border of the ilium to the middle of the cervical spine.

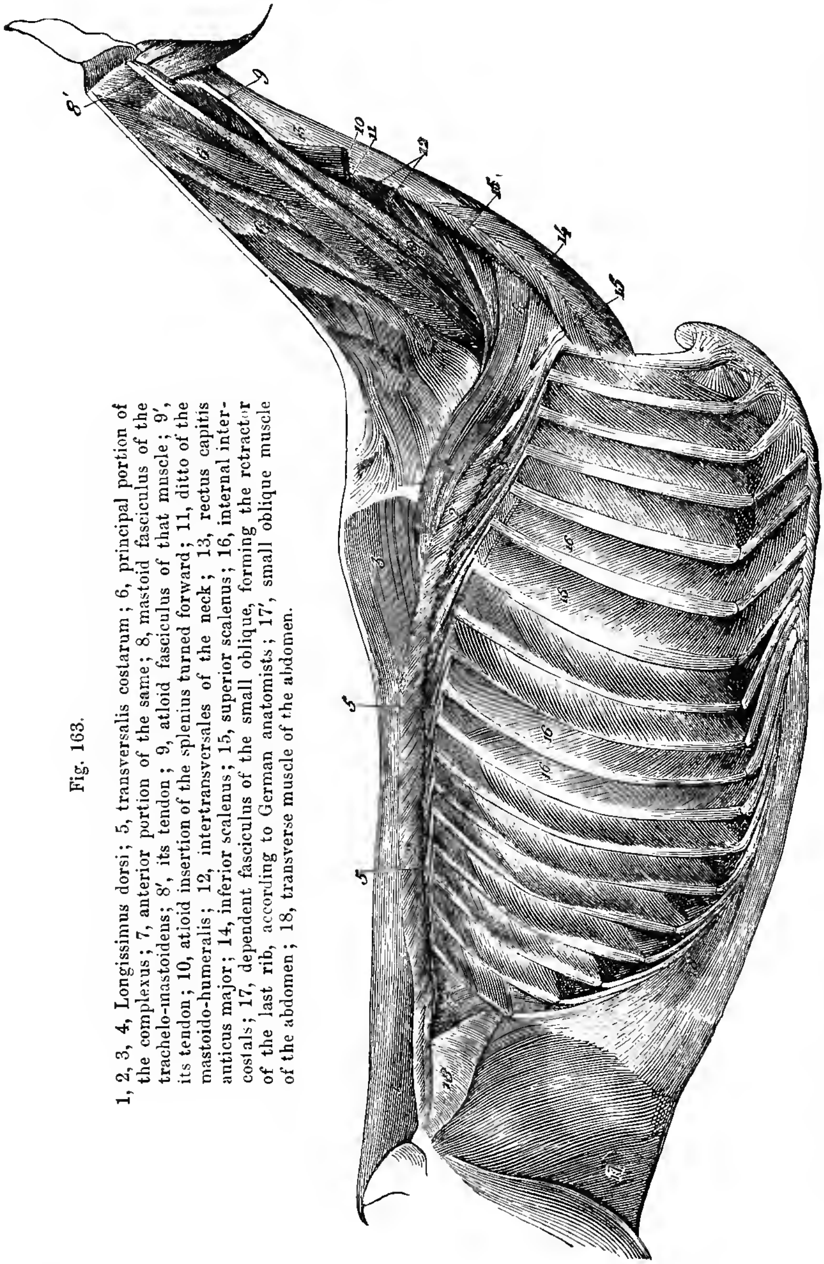
Form.—It is elongated from before to behind, and flattened above and below in its posterior half, which represents the *common mass* in Man; this mass is prismatic in form, thick inwards, and thin outwards. Anteriorly, it is flat on both sides, and bifurcates into two voluminous branches, a superior and inferior, between which pass the insertions of the complexus to be fixed into the transverse processes of the first dorsal vertebræ.

Attachments.—1. Upon the lumbar border, the external angle and internal surface of the ilium, the sacro-iliac ligament, and the sacrum. 2. To the spinous processes of all the lumbar and dorsal, and last four cervical vertebræ. 3. To the articular tubercles of the lumbar vertebræ and the transverse processes of all the dorsal, and the last four cervical vertebræ. 4. To the costiform processes of the lumbar vertebræ, and the external surface of the fifteen or sixteen last ribs.

Structure.—If this muscle is examined posteriorly, in the part which forms the *common mass*, it will be found to be composed of very compact fleshy fibres, covered in common by a thick aponeurosis. These fibres commence at the posterior extremity of the muscle, and all proceed forward, stopping to make successive insertions on the various bony eminences in its track, and forming three different orders of fasciculi, which are more or less tendinous at their anterior or terminal extremity. These fasciculi are *internal* and *superficial*, *internal* and *deep*, and *external.*

The *internal* and *superficial*, or *spinal* fasciculi, pass to the summits of the spinous processes already noticed when speaking of the attachments. These fasciculi are little, if at all distinct posteriorly; but they become more so anteriorly. About the sixth dorsal vertebræ, they separate from the other fasciculi to form the superior branch of the muscle (Fig. 163, 3).

The *internal* and *deep*, or *transverse* fasciculi, are those which attach the muscle to the articular tubercles of the lumbar vertebræ and transverse processes of the back and neck. They are well detached from each other, even posteriorly, and are very tendinous. Anteriorly, they pass into the inferior branch of the



DEEP MUSCLES OF THE SPINAL REGION OF THE NECK, BACK, AND LOINS, AND THE COSTAL AND INFERIOR ABDOMINAL REGIONS.

Fig. 163.

1, 2, 3, 4, Longissimus dorsi; 5, transversalis costarum; 6, principal portion of the complexus; 7, anterior portion of the same; 8, mastoid fasciculus of the trachelo-mastoideus; 8′, its tendon; 9, atloid fasciculus of that muscle; 9′, its tendon; 10, atloid insertion of the splenius turned forward; 11, ditto of the mastoido-humeralis; 12, intertransversales of the neck; 13, rectus capitis anticus major; 14, inferior scalenus; 15, superior scalenus; 16, internal intercostals; 17, dependent fasciculus of the small oblique, forming the retractor of the last rib, according to German anatomists; 17′, small oblique muscle of the abdomen; 18, transverse muscle of the abdomen.

longissimus dorsi, which they, in common with the external fasciculi, go to form. From profound, they now become superficial; and they are seen springing up between the others, which appear to separate to allow them to pass (Fig. 163, 4, 4).

The *external*, or *costal* fasciculi, turn a little outwards to reach the ribs and costiform processes of the lumbar region; they are not very apparent in this direction (Fig. 163, 2, 2).

It will be easily understood that all these fasciculi do not come from the common mass, which would be expended long before its termination at the neck, in consequence of the successive emissions of the fasciculi composing it. To prevent this exhaustion, there are continually added to it numerous bundles of fibres, which arise either from its aponeurotic envelope, or from the bones on which the primary fasciculi terminate, and comport themselves absolutely like these, which they are charged to continue to the neck.

Relations.—It is covered by the pyramidal point of the principal gluteal muscle, which it receives in a particular excavation, and by the aponeurosis of the latissimus dorsi and the small serrated muscles. It covers the inter-transversales of the lumbar region, the semispinalis of the back and loins, the levatores costarum, and the external intercostals. Outwards, it is bordered by the transversalis costarum.

The superior branch is covered by the complexus and the semispinalis colli. Inwardly, it responds to the cervical ligament and the analogous branch of the opposite muscle.

The inferior branch responds, outwardly, to the angularis of the scapula; it covers some intertransversales colli, and the aponeurotic digitations which attach the complexus to the transverse processes of the first dorsal vertebræ. From these digitations it even detaches a number of muscular fasciculi, which go to strengthen this branch of the longissimus dorsi.

Action.—It is a powerful extensor of the vertebral column, which, when it acts singly, it inclines to one side. It may also take part in expiration.

6. Common Intercostal Muscle (Transversalis Costarum (Fig. 163, 5).

Synonyms.—Trachelo-costalis—*Girard.* The *sacro-lumbalis* of Man.

Form—Situation.—A long, narrow, and thin muscle—particularly at its extremities—situated along the external border of the preceding muscle, with which it is confounded behind the last rib.

Structure—Attachments.—This muscle, the structure of which has been complicated by so many anatomists, is yet extremely simple. It is formed of a series of fasciculi, directed obliquely forwards, downwards, and outwards, tendinous at their extremities, and originating and terminating successively on the external surface of the ribs. The most posterior leave the external border and inferior face of the common mass. The tendinous digitation of the anterior fasciculus is inserted into the transverse process of the last cervical vertebra, in common with the inferior branch of the longissimus dorsi.

Relations.—Outwards, with the great and small serratus; inwards, with the external intercostals.

Action.—It depresses the ribs, and may extend the dorsal portion of the spine.

Fourth Layer.

Transverse Spinous Muscle of the Back and Loins (Semispinalis of the Back and Loins) (Fig. 161, 3).

Synonyms.—Transverso-spinous—*Girard.* *Dorso-lumbar portion* of the semispinalis of Man. (The *spinalis* and *semispinalis dorsi*—*Percivall.*)

Situation—Extent.—This is a very long muscle, directly applied to the supersacral and dorso-lumbar spine, and continuous, in front, with the semispinalis colli; these two muscles, therefore, measure nearly the whole length of the spine.

Structure.—It is formed by an assemblage of short fasciculi, which are flattened on both sides, tendinous at their extremities, directed obliquely forwards and downwards, and a little inwards, thus crossing at a right angle the spinous processes they cover.

Attachments.—These fasciculi are attached, below, to the lateral lip of the sacrum, the articular tubercles of the lumbar vertebræ, and the transverse processes of the dorsal vertebræ—*origin.* They are fixed, above, to the spinous processes of the sacral, lumbar, and dorsal vertebræ, and into that of the last cervical vertebra—*termination.* It is to be remarked that they do not attain the summits of these spinous processes in the first half of the dorsal region.

Relations.—Outwards, with the lateral sacro-coccygeal and longissimus dorsi muscles, which are confounded with it near its posterior extremity; inwards, with the sacral spine and the spines of the lumbar and dorsal vertebræ, and with the interspinous ligaments of these three regions.

Action.—It is an extensor of the spine.

Differential Characters in the Muscles of the Spinal Region of the Back and Loins in the other Animals.

A. **Ruminants.**—In the *Ox*, *Sheep*, and *Goat*, the *trapezius* is thick and very broad.

In the *Sheep*, only the posterior fasciculus of the muscle *annexed to the latissimus dorsi* is seen. Some of its fibres are prolonged to the anterior border and external face of the latissimus dorsi. In the *Camel*, the dorsal portion of the trapezius is remarkable for its size. The *latissimus dorsi* has a thicker and wider body than that of the Horse; it descends low on the ribs; the aponeurotic portion passes beyond the boss or hump. In the *longissimus dorsi*, the fasciculi are very distinct, even in the midst of the common mass, where the external fasciculi can be clearly seen to become attached separately to the extremities of the transverse processes of the lumbar vertebræ.

The *anterior small serrated muscle* is inserted, by its last digitation, into the ninth rib. The *posterior serrated* is fixed into the four last ribs.

B. **Pig.**—Its *trapezius* is well developed. The *latissimus dorsi* is voluminous, and is attached to the surface of the ribs, which it covers by digitations from its fleshy portion. It is fixed near the small trochanter to the lip of the bicipital groove. The inferior branch of the *longissimus dorsi* of this animal is easily divided into two portions, traces of which are found in the Horse: one is formed by the costal fasciculi, the other by the transversal fasciculi. The latter constitutes the muscle to which Bourgelat has given the name of short transversal.

C. **Carnivora.**—Several of the spinal muscles in the *Dog* resemble those of the Pig; such are the *trapezium*, the *latissimus dorsi*, and the *longissimus dorsi*. In animals of this group, it is remarked that the *anterior serrated* is very thick and very developed, and that it is attached to the eight ribs succeeding the second by as many well-marked festoons. The *posterior* has only three digitations, which are attached to the three last ribs. The *transversalis costarum* exactly resembles the sacro-lumbalis of Man; behind the last rib, it constitutes a thick fleshy body, separated by a fissure from the *longissimus dorsi*, with which it is attached to the coxa. Lastly, the *semispinalis of the back and loins* is very strong in the lumbar region, and is prolonged on the coccygeal vertebræ.

(According to Leyh, the semispinalis muscles are absent in the Horse and Ruminants; they are found in the Pig between the spinous processes of the dorsal and lumbar vertebræ, and in Carnivora between the spinous processes of the cervical vertebræ.)

Comparison of the Muscles of the Back and Neck in Man with the analogous Muscles in the domesticated Animals (Fig. 164).

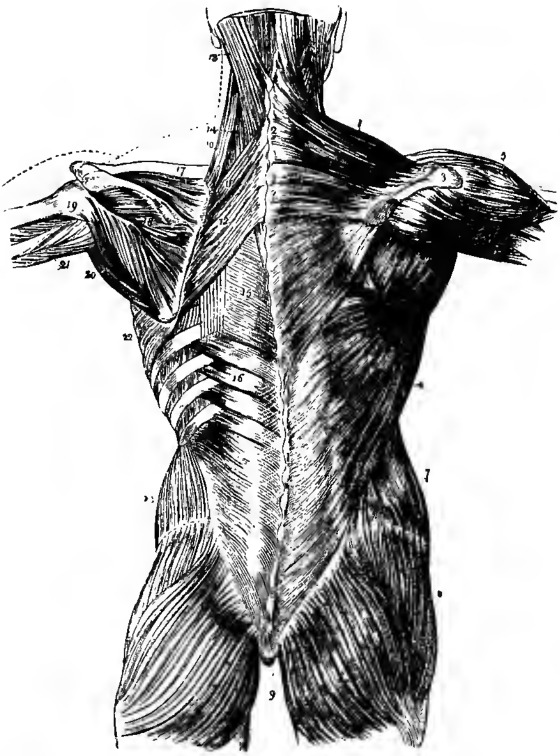
It is usual. in human anatomy, to describe by the name of muscles of the back and neck those which correspond to the superior cervical region, and those of the spinal region of the back and loins of the domesticated animals. The muscles of the inferior cervical region are described in Man as muscles of the neck, with the hyoid muscles and the scalenus.

1. Muscles of the Back and Cervix.

In the *trapezius* of Man, a cervical and a dorsal portion can no longer be distinguished. Above, it is attached to the superior occipital curved line; below, it is fixed to the external third of the upper border of the clavicle, and to the acromion and scapular spine. The fibres of the trapezius, which are fixed into the clavicle, represent a portion of the mastoido-humeralis of quadrupeds.

The *latissimus dorsi* resembles that of the Dog and Pig, its fleshy portion being very

Fig. 164.



FIRST, SECOND, AND PART OF THIRD LAYER OF MUSCLES OF THE BACK OF MAN; THE FIRST LAYER OCCUPIES THE RIGHT, THE SECOND THE LEFT SIDE.

Trapezius; 2, tendinous portion, forming, with a corresponding part of the opposite muscle, the tendinous ellipse on the back of the neck; 3, acromion process and spine of scapula; 4, latissimus dorsi; 5, deltoid; 6, muscles of dorsum of the scapula (infra-spinatus, teres minor, and teres major; 7, obliquus externus; 8, gluteus medius; 9, glutei maximi; 10, levator anguli scapulæ; 11, rhomboideus minor; 12, rhomboideus major; 13, splenius capitis, overlying the splenius, above; 14, splenius colli, partially seen (the common origin of the splenius is attached to the spinous processes below the origin of the rhomboideus major); 15, vertebral aponeurosis; 16, serratus posticus inferior; 17, supra-spinatus; 18, infra-spinatus; 19, teres minor; 20, teres major; 21, long head of triceps, passing between teres minor and major to the arm; 22, serratus magnus, proceeding forwards from its origin at the base of the scapula; 23, obliquus internus abdominis.

developed; it is attached to the external face of the four last ribs by muscular digitations, and terminates on the border of the bicipital groove.

The *rhomboideus* is bifid, as in the smaller Quadrupeds. Less developed than in these animals, the *levator anguli scapulæ* is only fixed in front to the four first cervical vertebræ.

In Man, the *splenius* is large, but by its insertions it resembles that of Solipeds. The *complexus*, thick and broad above, is incompletely divided into two fleshy bodies, which are attached, superiorly, to the sides of the external occipital crest. The trachelo-mastoideus is not fixed into the axis and atlas, its superior extremity passing directly to the mastoid process.

There is nothing particular to note regarding the *straight posterior* and *oblique muscles of the head;* the differences they offer in their form are allied to the conformation of the bones in this region.

Of the two *small serrated* muscles, that which corresponds to the anterior serrated of animals rises very high; for it is attached by an aponeurosis to the spinous processes of the three first dorsal vertebræ, the seventh cervical, and the cervical ligament.

There are found in Man, lying along the vertebral furrows, several muscles which represent the *longissimus dorsi* and the *transversalis costarum* of Solipeds. Thus the *common mass* covering the lumbar vertebræ behind, is prolonged by two series of fleshy and tendinous fasciculi; one forms the *sacro-lumbalis,* which resembles the *transversalis costarum* of animals; the other, the *long dorsal,* represents the inferior branch of the longissimus dorsi. The superior branch of the latter is found in the *semispinalis colli.*

Lastly, there are also seen in Man semispinalis and *intertransversalis muscles,* which correspond: the first, to the *semispinalis of the back and loins* and *semispinalis colli;* the second, to the *intertransversales of the loins* of the domesticated species.

2. Muscles of the Neck.

The *mastoido-humeralis* is not present in Man, being peculiar to Quadrupeds; but we should see a portion of its fasciculi in the *cleido-mastoideus muscle,* and in the *clavicular portions of the trapezius* and *deltoid.*

The *sterno-mastoideus* corresponds to the *sterno-maxillaris* of animals; as in the Dog, it is inserted into the external face of the mastoid process and the external two-thirds of the superior occipital curved line. Below, it commences by two fasciculi—one from the sternum, the other from the clavicle. We have already alluded to this clavicular fasciculus.

The *sterno-thyro-hyoideus* is large and well developed, resembling in its disposition that of the smaller animals. It is to be noted that the *sterno-hyoideus* portion leaves the sternum, the first costal cartilage, and the internal extremity of the clavicle. The *subscapulo-hyoideus* is digastric. The *anterior great straight muscle of the head* is attached to four cervical vertebræ, as in Ruminants and the Pig. The *anterior small straight,* the *lateral small straight,* and the *longus colli,* comport themselves as in the smaller animals. The *anterior scalenus* is very developed, for it is attached to the six last cervical vertebræ.

Sublumbar, or Inferior Lumbar Region.

The muscles of this region are deeply situated at the inferior face of the lumbar vertebræ and the ilium, concurring to form the roof of the abdominal cavity, and are in more or less direct contact with the viscera contained in that cavity. They are nine pairs. Three of these have received the generic name of *psoas,* and are of large volume; they are bound by a strong aponeurosis—the *iliac fascia,* and are distinguished as the *great psoas, iliac psoas* (or *iliacus*), and *small psoas.* A fourth is named the *square muscle of the loins* (*quadratus lumborum*). The other five, placed between the transverse processes of the lumbar vertebræ, represent, in consequence of their connection with these kind of fixed ribs, veritable intercostal muscles; these are the *intertransversales muscles of the loins.*

Preparation.—1. Place the subject in the first position: open the abdominal cavity by completely removing its inferior walls; empty the cavity of the viscera it contains, and excise the diaphragm, as that muscle prevents the anterior extremity of the great and small psoas muscles being seen. 2. First study the *iliac fascia,* its form, relations with the long abductor of the leg, its attachments, its continuity with the tendon of the small psoas, and the expansion reflected from the aponeurosis of the great abdominal oblique muscle. 3. Expose the three psoas muscles by removing the *iliac fascia,* the two adductors of the leg, and the three adductors of the thigh. 4 Remove the psoas muscles for the dissection of the quadratus and intertransversales.

1. Iliac Fascia, or Lumbo-iliac Aponeurosis (Fig. 165, a).

This is a very resisting fibrous expansion, covering the great psoas and iliacus muscles. Attached, inwardly, to the tendon of the small psoas, outwardly to the angle and external border of the ilium, this aponeurosis, as it extends forwards over the great psoas, degenerates into connective tissue. Behind, it also becomes attenuated in accompanying the two muscles it covers, until near their insertion into the internal trochanter of the femur. Its external or inferior face receives, posteriorly, the insertion of the crural arch, and gives attachment to the long adductor of the leg; for the remainder of its extent, it is covered by the peritoneum.

2. Great Psoas Muscle (Psoas Magnus) (Fig. 165, 1).

Synonyms.—Sublumbo-trochantineus—*Girard.* Psoas—*Bourgelat.* (*Lumbo-femoral—Leyh.*)

Form—Situation.—This is a long muscle, flattened above and below at its anterior extremity, prismatic in its middle, and terminated in a cone at its posterior extremity. It lies beneath the transverse processes of the lumbar vertebræ.

Structure.—Almost entirely fleshy, this muscle is formed of very delicate fasciculi, which are directed backwards, and long in proportion to their superficial and deep situation. They all converge to a tendon which is enveloped by the iliacus, and is confounded with it.

Attachments.—It is attached: 1. By the anterior extremity of its fleshy fasciculi to the bodies of the last two dorsal and the lumbar vertebræ, except the hindermost, and to the inferior face of the two last ribs and the transverse processes of the lumbar vertebræ. 2. By its posterior tendon to the internal trochanter, in common with the iliacus.

Relations.—Below, with the pleura, the superior border of the diaphragm, and the lumbo-iliac aponeurosis, which separates it from the peritoneum and the abdominal viscera situated in the sublumbar region; above, with the two last internal intercostals, the quadratus lumborum, and the intertransversales muscles; inwardly with the small psoas and the internal branch of the iliacus; outwardly, for its posterior third, with the principal branch of the latter muscle.

Action.—A flexor and rotator of the thigh outwards when its fixed point is the loins, this muscle also flexes the lumbar region when the thigh is a fixed point. It is, therefore, one of the agents which determine the arching of the loins, and which operate, during exaggerated rearing or prancing, in bringing the animal into a quadrupedal position again.

3. Iliac Psoas Muscle (Iliacus) (Fig. 165, 3).

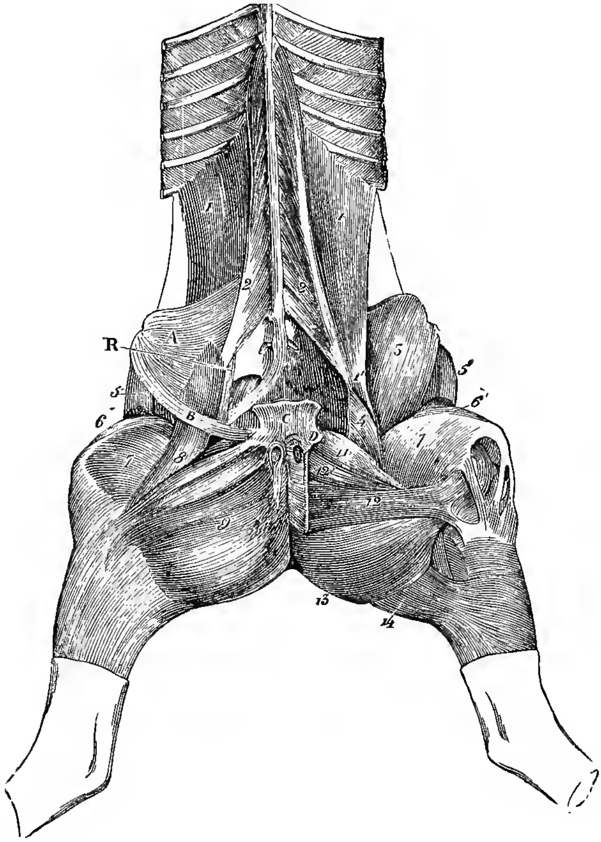
Synonyms.—Ilio-trochantineus—*Girard.* (Leyh divides this muscle into two portions, which he describes as the *great* and *middle ilio-femoralis.*

Form—Situation—Direction.—This is a very strong, thick, and prismatic muscle, incompletely divided into two unequal portions by the groove for the reception of the tendon of the great psoas: an external portion, somewhat considerable in size; and an internal, small. These two muscular portions lie at the entrance to the pelvis, on the inner face of the ilium, in an oblique direction downwards, backwards, and inwards.

Structure.—It is almost entirely fleshy. The fasciculi forming it are spread out in front, and collected behind, where they become slightly fibrous, and unite with the tendon of the great psoas.

Attachments.—It has its fixed insertion on the whole of the iliac surface, on the external angle of the ilium, the sacro-iliac ligament, and the ilio-pectineal

Fig. 165.



MUSCLES OF THE SUBLUMBAR, PATELLAR, AND INTERNAL CRURAL REGIONS.

1, Psoas magnus; 1′, its terminal tendon; 2, psoas parvus; 3, iliacus; 4, its small internal portion; 5, muscle of the *fascia lata;* 6, rectus femoris of the thigh; 7, vastus internus; 8, long adductor of the leg; 9, short adductor of the leg; 11, pectineus; 12, great adductor of the thigh; 12′, small adductor of the thigh; 13, semimembranosus; 14, semitendinosus. A, Portion of the *fascia iliaca*; B, portion of the membrane reflected from the aponeurosis of the abdominal great oblique muscle, forming the crural arch (Poupart's ligament); C, pubic tendon of the abdominal muscles; D, origin of the pubio-femoral ligament.

crest. Its movable insertion is into the small internal trochanter, in common with the great psoas.

Relations.—Above, with the ilium; below, with the iliac fascia and the long adductor of the leg; outwardly, with the muscle of the *fascia lata* and the origin of the rectus femoris, from which it is separated by a space filled with fat; inwardly, with the crural vessels. It passes between the vastus internus and the pectineus, to reach the trochanter.

Actions.—It is a flexor and rotator outwards of the thigh.

4. Small Psoas Muscle (Psoas Parvus) (Fig. 165, 2).

Synonyms.—Psoas of the loins—*Bourgelat.* Sublumbo-pubialis, or sublumbo-iliacus, according to Girard. (*Psoas parvus—Percivall.* The *lombo-iliacus* of Leyh.)

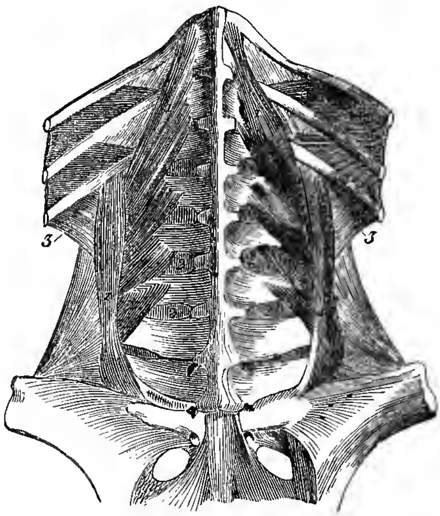
Situation—Form—Structure. Placed at the inner side of the psoas magnus, very much elongated, and semipenniform in shape, this muscle is terminated behind by a flattened tendon, and is composed of fleshy fibres, the longest of which are anterior. These fasciculi are all directed backwards and outwards to gain the tendon.

Attachments.—1. To the bodies of the three or four last dorsal, and to all the lumbar vertebræ, by the anterior extremity of its fleshy fibres. 2. To the ilio-pectineal line and the lumbo-iliac aponeurosis, by the posterior extremity of its tendon.

Relations.—By its inferior face with the pleura, the superior border of the diaphragm, the aorta or posterior vena cava, and the great sympathetic nerve; by its upper face, with the psoas magnus. It is traversed, near its vertebral insertions, by numerous vascular and nervous branches.

Actions.—It flexes the pelvis on the spine, when the loins are the fixed point; but should the pelvis be fixed, it arches or laterally inclines the lumbar region. It is also the tensor muscle of the lumbo-iliac aponeurosis.

Fig. 166.



DEEP MUSCLES OF THE SUBLUMBAR REGION.

1, Quadratus lumborum; 2, 2, intertransversales; 3, small retractor muscle of the last rib—a dependent of the small oblique of the abdomen.

5. Square Muscle of the Loins (Quadratus Lumborum) (Fig. 166, 1).

Synonyms.—Sacro-costalis—*Girard.* (*Sacro-lumbalis—Percivall. Quadratus lumborum* of Man.)

Situation—Form—Structure—Attachments.—This muscle is comprised between the transverse processes of the lumbar region and the psoas magnus, is elongated from before to behind, flattened above and below, and divided into several very tendinous fasciculi. The principal fasciculus, situated outwardly, takes its origin from the sacro-iliac ligament, near the angle of the sacrum, and extends directly forward to gain the posterior border of the last rib, after being attached by its upper face to the summits of the transverse processes of the lumbar vertebræ. The other fasciculi are longer as they are anterior; they leave the internal border of the first, and are directed obliquely forward and inward, to be fixed into the transverse processes of the majority of the lumbar vertebræ, and the inner face of the two or three last ribs.

Relations.—By its upper face, with the intertransversales, the small retractor of the last rib, and the fibrous fascia which unites that muscle to the small oblique of the abdomen. By its inferior face, to the psoas magnus.

Actions.—It draws the last ribs backwards, and inclines the lumbar spine to one side.

6. Intertransversales of the Loins (Fig. 166, 2, 2).

(*Synonym.—Intertransversales lumborum—Percivall.*)

These are very small flat muscles which fill the intervals between the transverse processes of the lumbar vertebræ. Their muscular fibres are mixed with tendinous fibres, and are carried from the anterior border of one transverse process to the posterior border of the other.

They respond, by their superior face, to the longissimus dorsi, and by their inferior face to the quadratus, as well as the psoas magnus. They act by inclining the lumbar region to one side.

Differential Characters in the Muscles of the Sublumbar Region in the other Animals.

In **Ruminants** and the **Pig,** the muscles of this region so closely resemble those of Solipeds, that a special description is unnecessary. It may be remarked, however, that the *quadratus lumborum* in the **Sheep** is very developed, and throws fibres as far forward as the four last ribs.

In the **Dog,** the *psoas magnus* is little developed, and only commences at the third, or even the fourth lumbar vertebra; the *iliacus* is very slender, particularly in its external portion; otherwise it is scarcely distinct from the psoas magnus, with which it may be said to form one muscle; the *psoas parvus* is relatively larger than the great; it is not prolonged into the pectoral cavity, and its anterior extremity is confounded with the *quadratus lumborum,* which is longer and stronger than in all the other animals.

Comparison of the Sublumbar Muscles of Man with those of Animals.

In human anatomy, by the names of *psoas* and *iliacus* are described the *psoas magnum* and *iliacus* of animals. The *psoas magnus* of **Man** is distinguished from that of Solipeds by its superior insertions, which do not go beyond the last dorsal vertebræ.

The *psoas parvus* is often absent: when present, it is attached, above, to the bodies of the twelve dorsal vertebræ; below, to the ilio-pectineal crest.

The *intertransversales* have been studied with the muscles of the back. The *quadratus lumborum,* classed by anthropotomists with the abdominal muscles, is distinctly divided into three series of fasciculi: *ilio-costal* fasciculi, which pass from the upper border of the ilium to the twelfth rib; *lumbo-costal* fasciculi, passing from the transverse processes of the three or four last lumbar vertebræ to the twelfth rib; and *ilio-lumbar* fasciculi, going from the iliac crest to the posterior face of the transverse processes of all the lumbar vertebræ.

Coccygeal Region.

This region is composed of four pairs of muscles destined for the movements of the tail; three, named the *sacro-coccygeal*, are disposed longitudinally around the coccygeal vertebræ, which they completely envelop; the fourth is designated the *ischio-coccygeus* (*compressor coccygeus*).

1. Sacro-coccygeal Muscles (Fig. 167, 1, 2, 3).

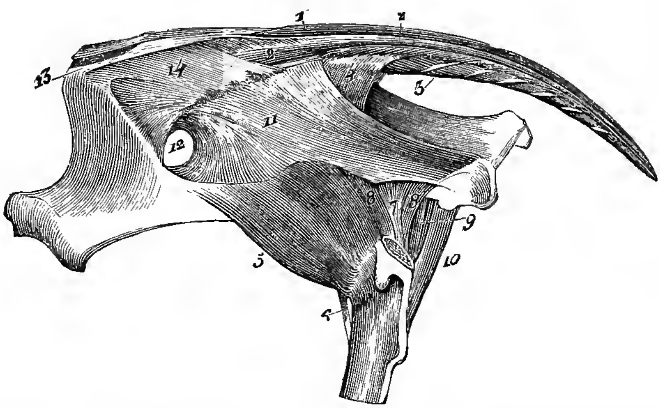
These three muscles are enclosed, with those of the opposite side, in a strong, common aponeurotic sheath, which is continuous with the inferior ilio-sacral and sacro-sciatic ligaments. They commence on the sacrum, are directed backwards and parallel with the coccyx, gradually diminishing in thickness, and are formed by several successive fasciculi terminating in small tendons, which are inserted into each of the coccygeal bones. With regard to their situation, these muscles are distinguished as *sacro-coccygeus superior*, *sacro-coccygeus inferior*, and *sacro-coccygeus lateralis*.

A. Sacro-coccygeus Superior (Erector Coccygis).—The fasciculi which form this muscle have their fixed insertion either in the summits and sides of the three or four last processes of the supra-sacral spine, or from the coccygeal vertebræ themselves. The tendons for their movable insertion into these vertebræ are always very short.

This muscle, covered by the coccygeal aponeurosis, in turn covers the vertebræ it moves. It responds : inwardly, to the analogous muscle of the opposite side; outwardly, to the lateral sacro-coccygeus, and, near its anterior extremity, to a very strong aponeurotic expansion which separates it from the semispinalis muscle. It directly elevates the tail, or pulls it to one side, according as it acts in concert with its fellow or singly.

B. Sacro-coccygeus Inferior (Depressor Coccygis).—This muscle is thicker than the preceding ; its constituent fasciculi take their origin from the

Fig. 167.



SACRO-ILIAC AND COXO-FEMORAL ARTICULATIONS, WITH THEIR SURROUNDING MUSCLES.

1, Sacro-coccygeus superior; 2, sacro-coccygeus lateralis; 3, sacro-coccygeus inferior; 4, ischio-coccygeus; 5, deep gluteus; 6, crureus.

inferior surface of the sacrum, towards the third vertebra, and from the internal face of the sacro-sciatic ligament and the coccygeal bones. It readily divides into two parallel portions, which Bourgelat has described as two separate muscles. The fasciculi of the internal portion are inserted, by their posterior extremity, into the inferior face of the first coccygeal vertebræ. Those of the external portion are furnished with strong superficial tendons, nearly all of which are for the bones of the tail.

This muscle responds : outwardly, to the sciatic ligament, the ischio-coccygeus (*compressor coccygeus*) and coccygeal aponeurosis ; inwardly, to the muscle of the opposite side, and to the coccygeal attachment of the rectum ; above, to the sacrum, the bones of the tail, and the lateral muscle ; below, to the rectum and the coccygeal aponeurosis.

It either directly depresses the tail or inclines it to one side.

C. Sacro-coccygeus Lateralis (Curvator Coccygis).—This muscle may be considered as the semispinalis of the coccygeal region ; indeed, it is confounded with that muscle of the back and loins by its anterior extremity, and appears to continue it to the inferior extremity of the tail.

The fasciculi composing it arise from the spinous processes of the last lumbar vertebræ, through the medium of the semispinalis, and from the coccygeal bones. The tendons terminating these fasciculi are deep and not very distinct.

It responds : outwardly, at the posterior extremity of the longissimus dorsi, to the inferior ilio-sacral ligament and the coccygeal aponeurosis ; inwardly, to the semispinalis and the coccygeal vertebræ ; above, to the superior muscle ; below, to the inferior muscle, from which it is nevertheless separated by several small independent muscular fasciculi, which are carried from one coccygeal vertebra to another. (Leyh designates these the *intertransversales of the tail.*)

It inclines the tail to one side.

2. Ischio-coccygeus (Compressor Coccygis) (Fig. 167, 4).

A small, thin, wide, and triangular muscle, situated against the lateral wall of the pelvis, at the internal face of the sacro-sciatic ligament.

It is attached, by an aponeurosis, to that ligament and to the ischiatic ridge ; it is then directed upwards to be fixed, by its muscular fibres, to the side of the last sacral vertebra and the first two coccygeal bones.

It is related, outwardly, with the sacro-sciatic ligament, and inwardly to the lateral sacro-coccygeus and the rectum.

It depresses the entire caudal appendage.

Region of the Head.

The head has a large number of muscles disposed around the mouth, nostrils, eyelids, the external ear, inferior maxilla, and os hyoides. They will be divided into five secondary regions.

A. Facial Region.

This region includes those muscles of the head which form a part of the framework of the lips, cheeks, and nostrils. Authors are far from being unanimous with regard to the nomenclature and description of these muscles. We recognise eleven, which are enumerated below, chiefly according to the nomenclature of Girard. They are : the *labial* (*orbicularis oris*) ; *zygomaticus ; supermaxillo-labialis* (*nasalis longus*, or *levator labii superioris proprius*) ; *maxillo-labialis* (*depressor labii inferioris*) ; *mento-labialis*, *suspensor of the chin* (*levator menti*), which act on the lips ; *alveolo-labialis* (*buccinator*), which moves the jaw ; *supernaso-labialis* (*levator labii superioris alæqui nasi*), which moves lips and nostrils ; *great supermaxillo-nasalis* (*dilatator naris lateralis*), *small supermaxillo-nasalis* (*dilatator naris superior*), *naso-transversalis* (*dilatator naris transversalis*), which dilate the nostrils and false nostrils only.

1. Labialis, or Orbicularis of the Lips (Orbicularis Oris) (Fig. 167, 27).

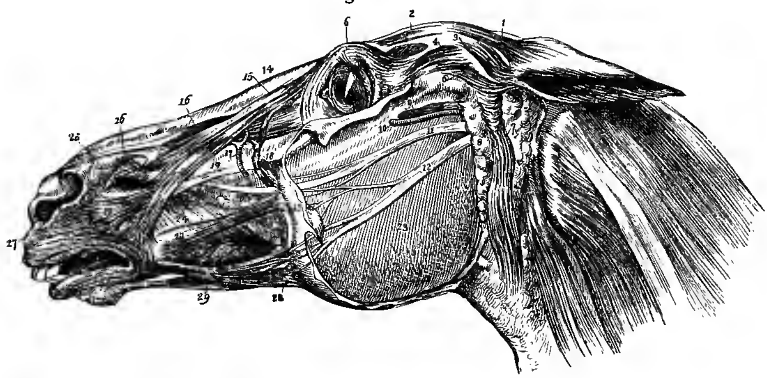
Preparation.—Remove with scissors the skin covering the two portions of this muscle; afterwards the buccal mucous membrane and subjacent glands within the lips, to expose its internal face.

The orbicularis, disposed as a sphincter around the anterior opening of the mouth, is regarded as the intrinsic muscle of the lips, and is composed of two portions or fasciculi—one for the upper, the other for the lower lip. United to each other at the commissures of the mouth, and confounded with the superficial layer of the buccinator, which they appear to continue, these two muscular portions also receive a large portion of the fibres belonging to the majority of the extrinsic muscles, such as the dilatator naris lateralis and levator labii superioris alæqui nasi.

The orbicularis is not attached to the neighbouring bone; its component fibres, affecting a circular form, have, consequently, neither beginning nor ending, except in being continuous with other fibres.

The internal face of the superior fasciculus responds to a layer of salivary glands, which in part separate it from the buccal mucous membrane. The external, covered by the skin, adheres to it in the most intimate manner, and is found isolated from it only on the median line, at first by the aponeurotic expansion of

Fig. 168.



SUPERFICIAL MUSCLES OF THE FACE AND HEAD.

1, Temporo-auricularis externus, or attollens maximus; 2, levator palpebræ, or corrugator supercilii; 3, temporo-auricularis internus, or attollens posticus; 4, 5, zygomatico-auricularis, or attollens anticus; 6, orbicularis palpebrarum; 7, abducens, or deprimens aurem; 8, parotid gland; 9, temporal, or subzygomatic vein; 10, ditto, artery; 11, 12, superior and inferior maxillary nerves · 13, fascia of the masseter muscle; 14, nasal bones; 15, supernasol-abialis, or levator labii superioris alæque nasi; 16, supermaxillo-labialis, or nasalis longus labii superioris; 17, external maxillary or facial artery; 18, facial vein; 19, supermaxillo-nasalis magnus, or dilatator naris lateralis; 20, superior maxillary nerve; 21, zygomatico-labialis, or zygomaticus; 22, parotid, or Steno's duct; 23, masseter; 24, alveolo-labialis, or buccinator; 25, supermaxillo-nasalis parvus, or nasalis brevis labii superioris; 27, labialis, or orbicularis oris; 28, maxillo-labialis, or depressor labii inferioris; 29, mento-labialis, or levator menti.

the nasalis longus, then by a musculo-fibrous layer analogous to that which forms the levator menti.

By its internal face, the inferior fasciculus likewise responds to the buccal mucous membrane, and to some salivary glands. By its external face, it forms an intimate union with the cutaneous integument, like the superior fasciculus.

This muscle plays the part of a constrictor of the anterior opening of the mouth, and has complex functions to perform in suction, the prehension of food, and in mastication.

2. Zygomatico-labialis (Zycomaticus) (Fig. 168, 21).

Synonyms.—Portion of the cuticularis of *Bourgelat.* The *zygomaticus major* of Man.

A very small, pale, and thin ribbon-like muscle, arising from the surface of the masseter, near the maxillary spine, by an aponeurosis which is confounded with the panniculus; it terminates on the surface of the buccinator, at a short distance from the commissure of the lips. Covered by the skin, it covers the buccinator, and some of the superior molar glands, vessels, and nerves.

When this muscle contracts, it pulls back the commissure of the lips.

In *Solipeds* there is also sometimes found a muscle resembling the *zygomaticus minor* of Man. It is a very small fasciculus situated under the preceding muscle, near its superior extremity. It appears that this fasciculus is continued, above, by the fibres of the lachrymal muscle, and is lost, below, on the buccinator surface, a little beneath the carotid canal.

3. Supermaxillo-labialis (Levator Labii Superioris Proprius, or Nasalis Longus) (Fig. 168, 16).

Synonyms.—Levator labii superioris of *Bourgelat.* The *levator labii superioris proprii* of Man. (*Nasalis longus labii superioris—Percivall.*)

Situation—Direction—Form—Structure.—Lying vertically on the side of the face, below the levator labii superioris alæque nasi, this muscle is a thick and conical fleshy mass, terminated inferiorly by a tendon.

Attachments.—It is attached, by the upper extremity of its fleshy body, to the external surface of the supermaxillary and zygomatic bones—*origin.* Its terminal tendon passes over the transverse muscle of the nose, to unite with that of the opposite side, and with it to form a single aponeurotic expansion, which dips by small fibres into the subcutaneous musculo-fibrous tissue of the upper lip.

Relations.—Covered by the lachrymal and levator superioris alæqui muscles, this muscle in turn covers the supermaxillary bone, the bottom of the false nostril, the dilatator naris inferioris, and the transversalis nasi.

Actions.—It raises the upper lip, either directly or to one side, as it acts singly or in concert with its congener on the opposite side.

4. Maxillo-labialis (Depressor Labii Inferioris) (Fig. 168, 28).

Synonyms.—Depressor labii inferioris—*Rigot.* A dependency of the buccinator of Man. (*Depressor labii inferioris—Percivall. Inferior maxillo-labialis—Leyh. Depressor anguli oris* of Man.)

Situation—Direction—Form—Structure.—Situated along the inferior border of the buccinator, and following its direction, this muscle forms a long narrow fasciculus, terminating inferiorly by an expanded tendon.

Attachments.—1. By its superior extremity, to the anterior border of the lower jaw, in common with the deep plane of the buccinator—*fixed origin.* 2. By its terminal tendon, to the skin of the lower lip—*movable insertion.*

Relations.—Outwardly, with the masseter and the facial portion of the cervical panniculus; inwardly, with the maxillary bone; in front, with the buccinator, with which it is directly united in its upper two-thirds.

Actions.—It separates the lower from the upper lip, and pulls it to the side if one alone acts.

5. Mento-labialis, or Muscle of the Chin (Levator Menti) (Fig. 168, 29).

(*Synonyms.*—Percivall appears to describe this and the next muscle as one, the *levator menti.* It is the *quadratus menti* of Man.)

This name is given to a musculo-fibrous nucleus, forming the base of the rounded protuberance beneath the lower lip in front of the beard. This single nucleus is confounded, in front, with the orbicularis of the lips, and receives into its upper face the insertion of the two posterior middle muscles (levatores menti).

6. Intermediate Posterior Muscle.

Synonyms.—Medius posterior—*Bourgelat.* (*Levator menti—Percivall. Incisive muscle of the lower lip—Leyh.*)

Bourgelat describes, by this name, a small muscular fasciculus, analogous in every respect to the medius anterior. This little muscle takes its origin from the external surface of the body of the lower jaw, beneath the intermediate and corner incisors; from thence it descends into the texture of the lip, to unite with that of the opposite side on the upper face of the mento-labialis. Several authors have described it as a dependent of the last muscle.

7. Alveolo-labialis (Buccinator) (Fig. 168, 24).

Synonyms.—Molaris externus et internus—*Bourgelat.* (*Buccinator—Percivall.* Leyh divides this muscle into two portions; its superficial plane he designates the *Buccinator*, and the deep plane the *Molaris.*)

Preparation.—Proceed to the ablation of the masseter; dissect the external surface of the muscle, taking care of the risorius Santorini and zygomaticus, which are confounded with it. Then divide it in the middle, as far as the commissure of the lips; turn down each strip on the jaws, and remove the mucous membrane, in order to study the inner face of the muscle and the attachments of the superficial plane to the maxillary bones.

Situation—Form.—Situated on the sides of the face, partly concealed by the masseter muscle, and applied to the mucous membrane of the cheeks, the buccinator is a flat, thin muscle, elongated in the direction of the head, and formed of two superposed planes.

Extent—Structure—Attachments.—The *deep plane*, the longest and least wide, is narrower at its extremities than its middle, and is formed of strongly aponeurotic muscular fasciculi, which are attached, posteriorly: 1. To the alveolar tuberosity. 2. To the external surface of the superior maxillary bone, above the last three molar teeth. 3. To the anterior border of the inferior maxillary bone, behind the sixth molar, in common with the depressor labii inferioris. On reaching the commissure of the lips, this muscular layer appears to be continued by small tendons with the fibres of the orbicularis.

The *superficial plane* only begins about the middle of the deep one, the anterior half of which it entirely covers. Its fibres, less tendinous than those of the latter, extend from a median raphé which also divides the deep layer in its length, and are directed, some forwards, some backwards, to terminate in the following manner: the first are inserted into the external face of the supermaxillary bone, above the first molar tooth and the superior interdental space; the second are attached to the inferior interdental space alone.

Relations.—Externally, with the masseter, zygomaticus, panniculus, dilator naris lateralis, levator labii superioris, the parotid duct, which crosses it to enter the mouth, and the facial artery and veins; internally, with the buccal mucous membrane. The deep plane is accompanied and covered at its anterior border by the upper molar glands; its posterior border is margined by the inferior molar teeth, which it partially covers. The superficial layer is distinctly separated from the deep one in its anterior part, which is attached to the supermaxillary bone. Behind, these two planes adhere more intimately to one another, though they are found completely isolated by an interstice in which one or two large veins pass.

Actions.—The function of the buccinator is particularly related to mastication: this muscle, in fact, pushes between the molar teeth the portions of food which fall outside the alveolar arches; but it cannot aid in bringing the two jaws together, as Lecoq has correctly observed.

8. Supernaso-labialis (Levator Labii Superioris Alæqui Nasi) (Fig. 168, 15).

Synonyms.—The maxillaris of *Bourgelat.* The *levator labii superioris alæque nasi* of Man. (*Levator labii superioris alæque nasi—Percivall. Fronto-labialis—Leyh.*)

Situation—Direction—Form—Structure.—Situated on the side of the face, in an oblique direction downwards and backwards, this is a wide muscle, flattened on both sides, elongated from below to above, aponeurotic at its superior extremity, and divided inferiorly into two unequal branches, between which passes the dilatator naris lateralis.

Attachments.—It has its origin, by its superior aponeurosis, from the frontal and nasal bones, and unites on the median line with the muscle of the opposite side. Its anterior branch, the widest and thickest, goes to the external ala of the nostril and to the upper lip, where its fibres are confounded with those of the orbicularis. The posterior branch terminates at the commissure of the lips.

Relations.—Outwards, with the skin ; inwards, with the levator labii superioris, the posterior portion of the dilatator naris superioris, and vessels and nerves. Its posterior branch covers the dilatator naris lateralis, and the anterior is covered by that muscle.

Actions.—It elevates the external ala of the nose, the upper lip, and the commissure of the lips.

9. Great Supermaxillo-nasalis (Dilatator Naris Lateralis) (Fig. 168, 19).

Synonyms.—The pyramidalis-nasi of Bourgelat. The *caninus* of Man. (*Dilatator naris lateralis—Percivall.*)

Situation—Direction—Form—Structure.—This muscle, situated on the side of the face, between the two branches of the levator labii superioris, in an almost vertical direction, is triangular in form, and slightly tendinous at its summit.

Attachments.—It has its origin, by the aponeurotic fibres of its summit, from the external face of the supermaxillary bone, below its ridge. It terminates, by its base, on the skin covering the external wing of the nostril, its most posterior fibres being confounded with those of the orbicularis of the lips.

Relations.—Outwardly, with the skin and the inferior branch of the levator labii superioris ; inwardly, with the anterior branch of that muscle, and with vessels and nerves.

Actions.—It dilates the external orifice of the nasal cavity, by pulling outwards the external wing of the nostril.

10. Small Supermaxillo-nasalis (Dilatator Naris Superioris) (Fig. 168, 25).

Synonyms.—The nasalis brevis, and portion of the subcutaneous muscle of Bourgelat. (*Nasalis brevis labii superioris—Percivall.*)

Girard has described, by the above name, a small, thick, and short muscular fasciculus which covers the external process of the premaxillary bone, the fibres of which, either originating from that, the supermaxillary bone, or the internal face of the levator superioris muscle, terminate in the skin of the false nostril, and the appendix of the inferior turbinated bone.

Rigot has attached to this muscle that described by Bourgelat as the short muscle. The latter is composed of short, transverse fibres, applied to the expansion of the cartilaginous septum of the nose which projects laterally beyond the nasal spine. These fibres abut, by their most eccentric extremities, against the skin of the false nostril and the appendix of the inferior turbinated bone.

To this muscle we may attach the small muscular fasciculus which Bourgelat has described as the *anterior intermediate.* To study it, it is necessary to raise the upper lip and remove the mucous membrane lining it. It is then seen that its fibres, attached to the inner side of the premaxilla, above the incisor teeth, ascend to meet those of the dilatator naris superior, and to terminate with them on the anterior appendix of the inferior turbinated bone ; some fibres become lost in the lips.

The dilatator naris superior acts as an external dilator of the nostril and false nostril. (Percivall names it the *depressor labii superioris.*)

11. Transversalis Nasi (Dilatator Naris Transversalis).

(*Synonym.—Dilatator naris anterior—Percivall*).

This muscle is in two parts : one, *inferior*, single, short, and quadrilateral, flattened on both sides, lies on the wide part of the nasal cartilages, forming transverse fibres ; the other, superior, pair muscle, formed of pale short fibres passing from the thin portion of the septum nasi which is laterally bordered by the nasal prolongation, to the skin of the false nostril and appendix of the upper turbinated bone. Covered by the skin and the aponeurotic expansion of the two elevator muscles of the upper lip, the transverse muscle of the nose covers the cartilages to which it is attached, and is confounded below with the orbicularis of the lips.

Designed to bring together the two internal alæ of the nose, this muscle ought to be considered more particularly as the dilator of the nostrils ; and, in addition, as an internal dilator of the false nostril.

B. Palpebral Region.

This region includes three muscles which act upon the eyelids or the skin in proximity to the orbit; these are the *Orbicularis Palpebrarum*, *Fronto-palpebral* (*Corrugator Supercilii*), *Lachrymalis.*

1. Orbicularis of the Eyelids (Orbicularis Palpebrarum) (Fig. 168, 6).

This muscle is a thin wide sphincter common to the two eyelids, and lying on the palpebral fibrous plate and the bones forming the margin of the orbit. Its external surface is covered by the skin, to which it adheres very closely. A small tendon which extends from the lachrymal tubercle to the nasal angle of the eye, is considered as the origin of the fibres of this muscle ; some of these—the most numerous—pass upwards and are distributed in a circular manner in the upper eyelid ; the others reach the lower eyelid and rejoin the numerous ones towards the temporal angle of the eye.

The contraction of this muscle determines the occlusion of the palpebral opening.

2. Fronto-Palpebral, or Corrugator Supercilii (Fig. 168, 2).

This is a short flat muscle, arising from the external surface of the frontal bone, and passing downwards and outwards to mix its fibres with those of the orbicularis at the supra-orbital foramen, which it covers, and the skin of the eye-brow. It has been erroneously considered as an elevator of the upper eyelid. When it contracts, it is limited to wrinkling the skin of the eyebrow in drawing it slightly to the nasal angle—which it can do whether the eyelids are in contact or apart.

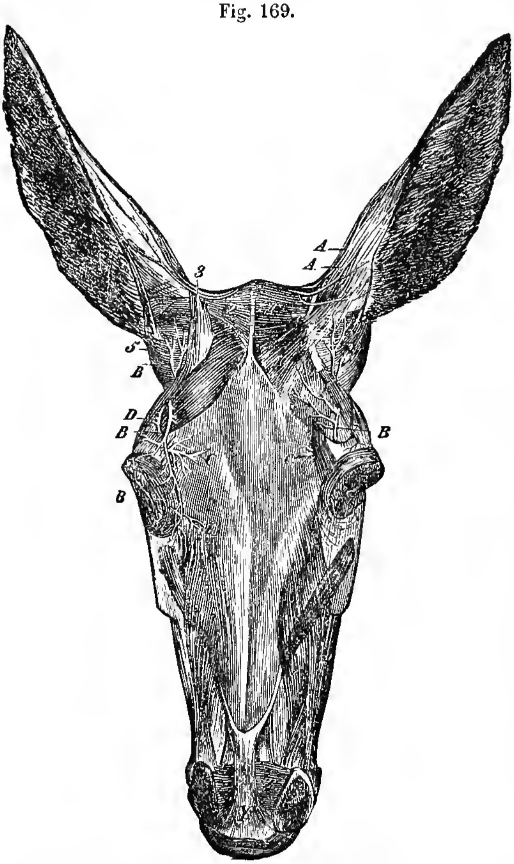
3. Lachrymalis Muscle.

(*Synonym.*—Not mentioned by Percivall. It is the *inferior palpebral* muscle of Leyh.)

A wide and very thin muscle, situated superficially below the eye. It is continuous, in front, with the panniculus; behind, with the levator labii superioris; above, with the orbicularis of the eyelids. Its fibres, partly muscular and partly aponeurotic, leave the external surface of the lachrymal and malar bones, are directed downwards, and become lost in a connective tissue fascia which covers the buccinator; some pass beneath the zygomaticus and form the zygomaticus minor, when this is present.

This muscle is supposed to corrugate and twitch the skin below the eye.

Fig. 169.



MUSCLES OF THE EXTERNAL EAR OF THE MULE.

1, 1, Attollens maximus; 2, attollens posticus; 3, scutiform cartilage; 4, scuto-auricularis externus. A, auricular branches of the first cervical nerve; B, anterior auricular nerve (from the facial); C, terminal branches of the superciliary nerve; D, superficial or temporal branch of the lachrymal nerve.

C. Auricular, or Conchal Region.

The muscles of this region move the *concha*, or *pavilion of the ear* (*concha auris*). The largest arise from the surface of the cranial bones or cord of the cervical ligament, and terminate on the cartilages of the external ear; the medium-sized pass from one cartilage to another; and the smallest are found on the surface of the concha, inside and out. The latter are really *intrinsic muscles*, but they are of so little importance that we will not describe them. The others are ten in number.

In the first plane we find the *zygomatico-auricularis* (*attolens anticus*), *temporo-auricularis externus* (*attolens maximus*), *scuto-auricularis externus*, three *cervico-auriculares* (*retrahens externus*, *medius*, *internus*), and *parotido-auricularis* (*abducens*); the second plane, the *temporo-auricularis internus* (*attolens posticus*), *scuto-auricularis internus*, *tympano-auricularis* (*mastoido-auricularis*).

Before studying these muscles, it is indispensable to examine the pieces of cartilage which form the concha. These are three in number: 1. *Conchal cartilage.* 2. *Annular cartilage.* 3. *Scutiform cartilage.*

1. Conchal Cartilage.—The principal portion of the pavilion, this cartilage determines its general configuration. In shape it resembles a trumpet with a wide opening on one side. Its *entrance* is elliptical, and elongated vertically, being circumscribed by two thin borders which unite above at a point that constitutes the summit (apex) of the organ. Its *base*, bulging in a *cul-de-sac*, terminates in front by a constricted infundibulum; it is attached to the margin of the auditory hiatus by means of the annular cartilage, to the surface of the guttural pouch by a pointed prolongation that descends outside this annular cartilage, beneath the parotid gland, and terminates by several fibrous filaments. This portion of the framework of the concha is a cartilaginous plate, rolled on itself in such a manner as to circumscribe, between its borders, the entrance to the ear, and to form, inferiorly, the complete infundibuliform canal just mentioned. (Externally, the integument of the ear is covered by ordinary hair, but internally there are long fine hairs, especially near the entrance; these prevent the intrusion of foreign substances.)

In **Ruminants,** this cartilage is thin, inclined outwards, and largely open. In the **Pig,** it differs slightly according to breed, but it is always much developed, sometimes erect, and more frequently drooping forward. It is always short, pointed, erect, and open towards the front in the **Cat.** In the **Dog,** it is sometimes short and straight; in others broad and pendant.

2. Annular Cartilage.—By this name is known a little ring-shaped plate, placed at the lower part of the conchal cartilage, intermediate between it and the auditory canal. The internal integumentary membrane, with some yellow elastic fasciculi, unites this cartilage to the other two portions between which it is situated. Its relations with these are such, that it receives within its lower border the bony circular prominence forming the margin of the auditory hiatus, while it may itself be received into the infundibuliform canal of the conchal cartilage—an arrangement resembling the tubes of a telescope.

3. Scutiform Cartilage.—This is a small cartilaginous plate, situated in front of the base of the concha, at the surface of the temporal muscle; it is irregularly triangular, is attached to the conchal cartilage by some muscular fasciculi, and transmits to that cartilage the action of some other muscles which are fixed on the cranial bones.

(The arteries of the concha proceed from branches of the external carotid, and the veins pass to a trunk of the same name; the nerves are divisions of the facial and the first cervical pair.)

An *adipose cushion*, placed at the base of the ear, facilitates the movements of the cartilages when they are acted upon by these muscles.

1. Zygomaticus-auricularis (Attollens Anticus) (Figs. 168, 4, 5; 170, 19).

This muscle is generally composed of two fleshy bands joined by connective tissue, and rising from the zygomatic process of the temporal bone by means of an aponeurosis common to it and the orbicularis palpebræ. The inferior of these two bands is inserted into the outside of the base of the concha, its fibres mixing with those of the abducens; the superior band terminates on the outer border of the scutiform cartilage.

Placed immediately beneath the skin, this muscle partly covers the superior extremity of the parotid gland, and the zygomatic process.

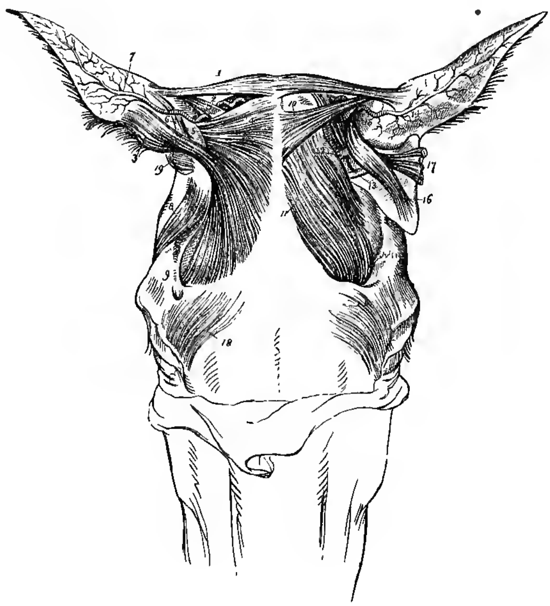
It draws the ear forward.

2. Temporo-auricularis Externus (Attolens Maximus) (Figs. 168, 1; 169, 1, 1; 170, 3, 4).

A very thin, wide muscle, covered by the skin, lying on the temporal muscle, united posteriorly to the retrahens externus, in front and outwardly to the attollens maximus. It arises from the whole of the parietal crest or ridge,[1] mixing in its upper half or third with the muscle of the opposite side; it terminates, by one portion, on the inner margin of the scutiform cartilage, and by another, on the inner side of the conchal cartilage, by means of a thin fascia that covers part of the former cartilage and the external scuto-auricularis.

It acts as an adductor of the concha, drawing it inwards; it also carries it

Fig. 170.



MUSCLES OF THE EAR.

1, Retrahens externus; 2, attollens posticus; 3, 4, attollens maximus; 5, scutiform cartilage; 6, scuto-auricularis externus; 7, posterior auricular artery; 8, portion of the zygomaticus-auricularis; 9, orbital process; 10, temporo-auricularis internus; 11, temporal muscle; 12, scutiform cartilage; 13, ditto; 14, concha of the ear; 15, scuto-auricularis externus; 16, internal scuto-auricularis; 17, abducens; 18, corrugator supercilii; 19, zygomaticus-auricularis.

forwards, and concurs in making it pivot on itself, so as to bring the opening of the ear forward.

3. Scuto-Auricularis Externus (Figs. 169, 4; 170, 6).

This muscle may be said to be a dependency of the preceding, the action of which it transmits to the conchal cartilage, and renders it more complete.

Extending from the external face of the scutiform cartilage to the inner side

[1] Owing to this crest bordering the temporal fossa, Girard has thought proper to give to the two muscles of the ear attached thereto, the name of temporo-auriculares; but it would be more appropriate to designate them the *parieto-auriculares*.

of the concha, and generally composed of two fasciculi, it is covered by the skin and the conchal band of the attollens maximus, while it covers part of the internal scuto-auricularis muscle.

When this muscle contracts, it principally participates in producing the rotatory movement that carries the opening of the concha outwards.

4. Cervico-auriculares (Retrahentes Aurem) Muscles (Fig. 168).

Three in number, and situated behind the ear, these muscles are broad, thin bands, extending from the cervical ligament to the conchal cartilage. With regard to their position at their origin, they may be distinguished as *external*, *middle*, and *internal*; the situation of their point of insertion in the concha also permits their being classed as *superior*, *middle*, and *inferior*.

The *retrahens externus*, or *superior* or *superficial cervico-auricularis*, closely united to the attollens maximus, and covered by the skin, covers the medius and internus muscles. Attached by its terminal extremity to the middle of the posterior face of the concha, it draws that cartilage backwards and downwards.

The *retrahens medius*, or *middle cervico-auricularis*, comprised at its origin between the other two, and intimately attached to them, especially the deep one, is in relation with the skin for the greater part of its superficies. Its terminal extremity is very wide and thin, and passes over the upper end of the parotid gland, to be inserted outwardly into the base of the concha, after being slightly insinuated beneath the abducens. This is a rotator muscle, turning the opening of the ear outwards and backwards.

The *retrahens internus*, or *inferior* or *deep cervico-auricularis*, concealed beneath the upper extremity of the parotid, to which it adheres closely, is inserted at the base of the concha. Its action is similar to that of the middle muscle.

5. Parotido-auricularis (Abducens, or Deprimens Aurem) (Figs. 168, 7; 170, 17).

Lying on the external face of the parotid gland, this is a long, thin, ribbon-like band, narrower and thicker at its upper than its lower extremity. It arises on the tissue of the gland, and terminates outside the base of the concha, below the inferior commissure formed by the two borders of that cartilage.

Covered externally by a very thin portion of the cervico-facial panniculus, the abducens is an abductor of the ear, inclining it outwards.

6. Temporo-auricularis Internus (Attollens Posticus) (Fig. 170, 2).

Situated beneath the superficial muscle of this name, and partly covered by the retrahens externus, this muscle is long and triangular in shape, bright-red in colour, and extending transversely on the surface of the temporalis; it is attached, inwardly, to the sagittal or spur-like ridge of the parietal bones, and outwardly, by means of a small tendon, to the inner side of the concha, within the terminal insertion of the retrahens externus auricularis. It is an adductor of the ear.

7. Scuto-auricularis Internus (Fig. 170, 16).

This is a muscle composed of two short, pale fasciculi, which cross each other very obliquely, are concealed beneath the scutiform cartilage and the scuto-auricularis externus, and lie directly on the adipose cushion of the ear. They arise from the inner face of the scutiform plate, pass backwards, and terminate at the base of the concha, behind the infundibuliform cavity which that cartilage forms at its root. This muscle is antagonistic to the external muscle of this name, as it turns the opening of the ear outwards, and even backwards.

8. Mastoido-auricularis.

This name is given to a very thin fasciculus lying vertically on the inner side of the cartilage, at the entrance to the ear. Arising from the margin of the auditory external hiatus, and attached to the base of the concha, this little muscle, in contracting, constricts the cartilaginous tube with which it is in contact.

D. Masseteric, or Temporo-maxillary Region.

This region comprises five pair-muscles for the movement of the lower jaw. These are: the *masseter*, *temporalis*, *pterygoideus internus*, *pterygoideus externus*, and *digastricus*.

Preparation.—1. First study the digastricus and its stylo-maxillary portion, with the internal pterygoid, in preparing the hyoid muscles as they are represented in Fig. 171. 2. Expose the pterygoideus externus, by removing in this preparation the hyoid bone and its dependencies, as well as the two preceding muscles. 3. To dissect the temporalis, excise the external pterygoideus from its inferior border, an operation which exposes the orbital fasciculus of the temporalis; then turn over the piece, saw off the orbital process at each end, and remove the eye and auricular muscles. 4. Dissect the masseter, in clearing away from its external surface the cuticularis and the vessels and nerves which cover it.

1. Masseter (Fig. 168, 23).

Synonyms.—Zygomatico-maxillaris—*Girard.*

Situation—Form—Structure.—Applied against the external face of the branch of the lower jaw, the masseter is a short, wide, and very thick muscle, flattened on both sides, irregularly quadrilateral, and formed of several superposed planes, two of which are perfectly distinct towards the temporo-maxillary articulation, by the somewhat different direction of their fibres. These are divided by a considerable number of intersections, and are covered by a strong aponeurotic layer, which becomes gradually thinner backwards and downwards.

Attachments.—The fasciculi of the masseter have their fixed insertion on the zygomatic crest. Their movable insertion is on the imprints which cover the upper half of the ramus of the inferior maxilla.

Relations.—It responds, by its superficial face, to the facial portion of the cervical panniculus, to the nerves of the zygomatic plexus, and several venous and arterial vessels; by its deep face, to the inferior maxillary bone, the buccinator and depressor labii inferioris muscles, the superior molar glands, and two large venous branches; by its inferior border, with the parotid duct, and the glosso-facial artery and vein; by its superior and posterior border, to the parotic gland. Its deep plane responds, anteriorly, with the temporo-maxillary articulation, and is so intimately confounded with the temporalis, that it is impossible to define the respective limits of the two muscles.

Action.—This muscle, the special elevator of the lower jaw, plays an important part in mastication. It always acts as a lever of the third class—the middle line, which represents the resultant of all its constituent fibres, passing behind the last molar.

2. Temporalis.

Synonyms.—Temporo-maxillaris—*Girard.*

Situation—Form—Structure.—Situated in the temporal fossa, to which it is moulded, and which it fills, this muscle is flattened from above to below, divided by strong tendinous intersections, and covered by a nacrous aponeurotic layer.

Attachments.—It takes its origin: 1. In the temporal fossa and on the bony crests which margin it. 2. By a wide fasciculus, paler than the other portion of the muscle, but not unconnected with it, from the imprints situated behind the crest surmounting the orbital hiatus. It terminates on the coronoid process and the anterior border of the branch of the lower jaw.

Relations.—This muscle covers the temporal fossa, and is covered by the attollens muscles, scutiform cartilage, internal scuto-auricularis, the fatty cushion at the base of the ear, and by another adipose mass which separates it from the ocular sheath. Its deep fasciculus responds, by its internal face, to the two pterygoid muscles.

Action.—It brings the lower jaw in contact with the upper, by acting as a lever of the first kind; but the orbital portion of the muscle elevates the inferior maxilla and moves it laterally by a lever of the third kind.

3. Pterygoideus Internus.

Synonyms.—Portion of the spheno-maxillaris of Bourgelat.

Situation—Form—Structure.—Situated in the intermaxillary space, opposite the masseter, the pterygoideus internus, although not so strong as that muscle, yet so closely resembles it in form and structure as to be named by Winslow the *internal masseter.*

Attachments.—1. To the palatine crest and subsphenoidal process—*fixed insertion.* 2. In the hollow excavated on the inner face of the branch of the lower jaw—*movable insertion.*

Relations.—Outwardly, with the pterygoideus-externus, the orbital fasciculus of the temporal, the maxillo-dental nerves, mylo-hyoideal, and lingual muscles, arteries and veins, and the inner surface of the bone which receives its movable insertion. Inwardly, with the tensors palati—external and internal, the guttural pouch, the hyoideus magnus, hyoid bone, digastricus, the hypoglossal and glosso-pharyngeal nerves, glosso-facial artery and vein, the hyoglossus longus and brevis muscles, the laryngo-pharyngeal apparatus, the Stenonian duct, and the submaxillary glands.

Action.—It is an elevator of the lower jaw, and also gives it a very marked lateral or diductive motion. If the left muscle acts, this movement carries the inferior extremity of the lower jaw to the right; if it be the right muscle, then in the contrary direction.

4. Pterygoideus Externus.

Synonym.—Portion of the spheno-maxillaris of Bourgelat.

Form—Situation—Structure—Attachments.—A small, short, and very thick muscle, situated within and in front of the temporo-maxillary articulation, formed of slightly tendinous fasciculi which leave the inferior face of the sphenoid bone and the subsphenoidal process, and are directed backwards and upwards to be fixed to the neck of the inferior maxillary condyle.

Relations.—Outwardly, with the orbital fasciculus of the temporalis muscle and the temporo-maxillary articulation. Inwardly, with the numerous nerves emanating from the inferior maxillary branch, and with the internal pterygoid and tensors palati.

Action.—When the two external pterygoids act in concert, the inferior maxilla is pulled forward; but if only one contract, the propulsion is accompanied by a lateral movement, during which the extremity of the jaw is carried to the opposite side.

5. Digastricus (Stylo-maxillaris).

Synonyms.—Bourgelat has made two distinct muscles of this—the digastricus and stylo-maxillaris. Girard has described it as the stylo-maxillaris. (Percivall has evidently followed Bourgelat's example, and divided the muscle into *digastricus* and *stylo-maxillaris.* Leyh adopts the same course.)

Form—Structure—Situation—Direction.—Composed of two fleshy bodies more or less divided by intersections, and united at their extremities by a median tendon, this muscle is situated in the intermaxillary space, and extends from the occiput to near the symphysis of the chin, describing a curve upwards.

Attachments.—It takes its origin from the styloid process of the occipital bone, by its superior fleshy body. It terminates: 1. On the curved portion of the posterior border of the lower jaw by a considerable fasciculus, which is detached from the superior fleshy body.[1] 2. On the internal face of the same bone and the straight portion of its posterior border, by aponeurotic digitations which succeed the muscular fibres of the inferior fleshy body.

Relations.—The superior belly of the muscle responds, superficially, to the parotid gland and the tendon of insertion of the sterno-maxillaris; deeply, to the guttural pouch, the submaxillary gland, and the larynx and pharynx. The median tendon passes through the ring of the hyoideus magnus. The lower belly is in contact, outwards, with the ramus of the inferior maxilla; inwards, with the mylo-hyoideus muscle.

Action.—When this muscle contracts, it acts at the same time on the hyoid bone, which it raises in becoming straight, and on the lower jaw, which it pulls backwards and depresses at the same time.

E. Hyoideal Region.

This region includes six muscles grouped around the os hyoides, which they move. Five of these are pairs: the *mylo-hyoideus*, *genio-hyoideus*, *stylo-hyoideus*, *kerato-hyoideus* (*hyoideus parvus*), and the *occipito-styloideus*. The single one is the *hyoideus transversus*.

Preparation.—Separate the head from the trunk, and remove the muscles of the cheeks on one side, with the parotid gland. 2. The branch of the inferior maxilla being thus exposed, it is sawn through in two places; at first behind the last molar, then in front of the first. 3. After having separated the pterygoids and the stylo-maxillaris from the upper fragment or condyle, and the coronoid process, it is torn off by pulling it backwards; then the pterygoids and digastricus are excised. 4. The inferior fragment of the jaw bearing the molar teeth is

[1] This is the fasciculus which Bourgelat has described as a distinct muscle, and named the *stylo-maxillaris.*

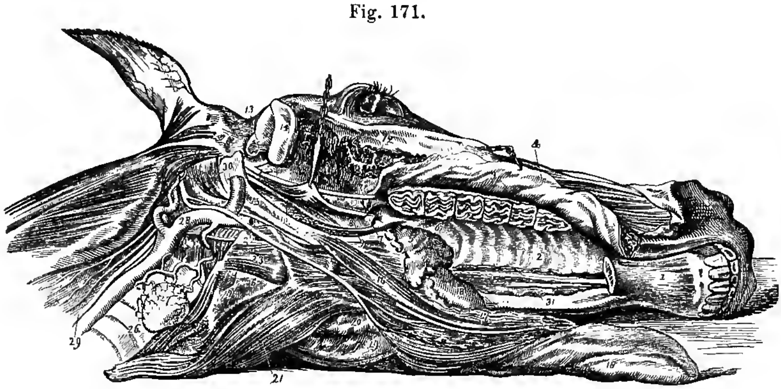
turned down by isolating the mylo-hyoideus from the mucous membrane. 5. Carefully remove the tongue by separating its extrinsic muscles from the genio-hyoideus, the anterior appendix of the hyoid bone, the transverse muscle, and the small hyoideus.

The dissection having been performed in this manner, the large hyoideal branch may be separated from the small, by sawing through the head longitudinally, leaving the symphysis menti intact, and turning down the corresponding half to the side already dissected, as well as the great hyoid branch, the pharynx, larynx, and soft palate.

1. Mylo-hyoideus.

Form—Situation—Structure.—A membranous muscle situated in the intermaxillary space, flattened from side to side, elongated in the direction of the head, thinner and narrower below than above, and formed entirely of fleshy fibres which extend transversely from its anterior to its posterior border. Inferiorly, it is composed of a small fasciculus, which is distinguished from the principal

Fig. 171.



HYOIDEAL AND PHARYNGEAL REGIONS.

1, Neck of inferior maxilla; 2, hard palate; 3, molar teeth; 4, buccal membrane; 5, submaxillary glands; 6, soft palate; 7, tendon of hyoideus magnus through which the tendon, 8, of the digastricus passes; 9, lower portion of digastricus; 10, stylo-hyoideus; 11, buccal nerve; 12, zygomatic arch; 13, orbital branch of fifth pair of nerves; 14, articular process of temporal bone; 15, right cornu of hyoid bone; 16, hyo-glossus longus, or Kerato-glossus; 17, lingual nerve; 18, 18, tongue; 19, angle of left branch of inferior maxilla; 20, submaxillary gland, left side; 21, subscapulo-hyoideus; 22, great hypoglossal nerve; 23, hyo-thyroideus; 24, sterno-hyoideus; 25, sterno-thyroideus; 26, subscapulo hyoideus; 27, thyroid gland; 28, external carotid artery; 29, pneumogastric nerve; 30, stylo-hyoideus; 31, genio-hyoideus.

portion by the slightly different direction of its fibres, and which covers in part the external surface of the muscle.

Attachments.—It originates from the mylo-hyoid line by the anterior extremities of its fibres. Its movable insertion takes place on the inferior face of the hyoid body, on its anterior appendix, and on a fibrous raphé which extends from the free extremity of this appendix to near the genial surface, and which unites, on the median line, the two mylo-hyoidean muscles.

Relations.—By its external face, with the inferior maxilla, the digastricus, and the submaxillary lymphatic glands. By its internal face, with the sublingual gland, the Whartonian duct, the hypoglossal and lingual nerves, the genio-glossus, hyo-glossus longus and brevis, and genio-hyoideus. Its superior border responds to the internal pterygoid.

Action.—In uniting on the median line with that of the opposite side, this muscle forms a kind of wide band or brace on which the tongue rests. When it contracts, it elevates this organ, or rather applies it against the palate.

2. Genio-hyoideus.

Form—Structure—Situation.—A fleshy, elongated, and fusiform body, tendinous at its extremities, but especially at the inferior one, and applied, with its fellow of the opposite side, to the mylo-hyoidean brace.

Attachments.—By its inferior extremity it is fixed to the genial surface—*origin*; by its superior, it reaches the free extremity of the anterior appendix of the hyoid body—*termination.*

Relations.—Outwards and downwards, with the mylo-hyoideus; inwards, with its fellow, which is parallel to it; above, with the genio-glossus.

Action.—It draws the hyoid bone towards the anterior and inferior part of the intermaxillary space.

3. Stylo-hyoideus.

Synonyms.—The *hyoideus magnus of* Percivall. The *kerato-hyoideus magnus* of Leyh.

Form—Structure—Situation—Direction.—Thin and fusiform, this muscle, smaller than the preceding, and, like it, tendinous at both its extremities, is situated on the side of the laryngo-pharyngeal apparatus and the guttural pouch, behind the large branch of the hyoid bone, the direction of which it follows.

Attachments.—Above, to the superior and posterior angle of the styloid bone—*fixed insertion*; below, to the base of the cornu of the os hyoides—*movable insertion.*

Relations.—Outwards, with the pterygoideus internus; inwards, with the guttural pouch, the pharynx, and hypoglossal nerve. Its anterior border is separated from the posterior border of the styloid bone by the glosso-facial artery and glosso-pharyngeal nerve; along the posterior border lies the upper belly of the digastricus. Its inferior tendon is perforated by a ring for the passage of the cord intermediate to the two portions of the latter muscle.

Action.—It is antagonistic to the preceding muscle, drawing the body of the hyoid bone backwards and upwards.

4. Kerato-hyoideus (Hyoideus Parvus).

(*Synonyms.*—This is the *hyoideus parvus* of Percivall, and the *small kerato-hyoideus* of Leyh.)

A very small fasciculus, triangular in shape, and flattened on both sides. Inserted, *on one side*, into the posterior border of the styloid cornu and the inferior extremity of the styloid bone; and *on the other*, to the superior border of the thyroid cornu. It responds, outwardly, to the hyo-glossus brevis and the lingual artery; inwardly, to the buccal mucous membrane.

It approximates the cornua of the os hyoides to each other.

5. Occipito-styloideus.

Synonyms.—This is the muscle which, up to the present time, has been described by veterinary anatomists as the *stylo-hyoideus.* This name has been given to the muscle named by Girard the *kerato-hyoideus magnus.*

A small, flat, and triangular muscle like the preceding, yet thicker and more spread, filling the space comprised between the styloid process of the occipital and the horizontal portion of the posterior border of the styloid bone. Its fasciculi become longer as they are situated posteriorly, are rather tendinous, and are carried from one of these bones to the other. Outwardly, it responds to the parotid gland; inwardly, to the guttural pouch, which it covers for its whole extent; its posterior border is largely confounded with the superior insertion of the digastricus. When this muscle acts, it causes the os hyoides to swing, carrying its inferior extremity backwards and downwards.

6. Hyoideus Transversus.

By this name Bourgelat has described a short riband of parallel muscular fibres, which unites the superior extremities of the styloid cornua, and approximates them to each other.

Differential Characters of the Muscles of the Head in the other Animals.

1. Facial Region.

Ruminants.—There are found in the *Ox:*

1. An *orbicular muscle of the lips*, analogous to that in the Horse.
2. A *buccinator* of the same kind (Fig. 172, 5).
3. A *zygomaticus*, stronger and redder than in Solipeds. Its aponeurosis of origin, covered by the panniculus, extends upon the surface of the masseter muscle as far back as the zygomatic arch, to which it is attached (Fig. 172, 7).
4. A *levator labii superioris alæqui nasi*, continued, above, with the inferior border of the frontal or fronto-cuticularis muscle; and divided, inferiorly, into two branches, which comprise between them the levator labii superioris and the dilator naris lateralis. These two branches, however, are not disposed as in Solipeds, the anterior covering the preceding muscles, and the posterior, of but little importance, passing beneath them to lose itself in the substance of the upper lip (Fig. 172, 3).
5. A levator labii superioris proprius, which gains the middle of the muzzle by passing along the inner side of the nostrils (Fig. 172, 1).
6. Two additional *levator labii superioris* muscles to the above, considered as accessories to the first, and which originate with it. Each terminates by a ramifying tendon that passes under the nostril to mix in the tissue of the upper lip (Fig. 172, 1′, 1′).
7. A *dilator naris lateralis*, situated between the supermaxillo-labialis and its two accessory muscles, and deriving its origin, in common with these three muscles, in front of the maxillary spine (Fig. 172, 2).
8. A *depressor labii inferioris*, confounded with the buccinator, and having no terminal tendon.
9. A *levator menti*, attached to the body of the inferior maxillary bone, as in the Horse, by two *middle posterior* muscles. No anterior middle muscle has been found by us; and it is certain that there is no *dilator naris transversalis* or *dilator naris superioris* present.

In the *Sheep*, the *levator labii superioris* does not exist; apart from this peculiarity, there is no difference between the facial muscles of this animal and the Ox.

Pig.—This animal has no *levator labii superioris*, or *dilator naris transversales* muscles. The *dilator naris superior* is present; it is short, very thick, and situated near the margin of the nostrils. The *levator labii superioris proprius* and the *dilator naris lateralis* are replaced by three fleshy bodies, nearly parallel, lying on the side of the face. The superior originates in the lachrymal fossa, and terminates by a tendon in the middle of the snout. The inferior, with the middle, leaves the imprints in front of the zygomatic ridge, and is continued at its inferior extremity by a tendon divided into several fibrillæ, which pass below the nostril to be united to the tendon of the superior portion: this is done in such a manner that the external opening of the nose is encircled on the inner side by a kind of fibrous cravat, which, when these two muscles contract, carries this opening outwards. It will also be understood that the superior fleshy body, acting alone, ought to elevate the snout, while the inferior depresses it in drawing it to one side. With regard to the intermediate fleshy mass, it is the representative of the *dilator naris lateralis* of the Ox, and terminates in a great quantity of tendinous fibrillæ at the internal ala of the nose.

Carnivora.—In the *Dog* and *Cat* the following peculiarities are found:—

The *orbicularis oris* is quite rudimentary.

The *buccinator* is very thin, and formed of only one muscular plane.

The *zygomaticus* is continued, superiorly, with the attollens anticus.

The *levator labii superioris* represents a wide, undivided, muscular expansion, united superiorly to the panniculus of the forehead, and terminating inferiorly on the upper lip.

The *levator labii superioris* and *dilator naris lateralis* constitute a single fleshy body formed of several parallel fasciculi, which take their origin above the supra-orbital foramen, and terminate together at the external wing of the nose and in the upper lip.

There is no *dilator naris superioris*, or *dilator naris transversalis.*

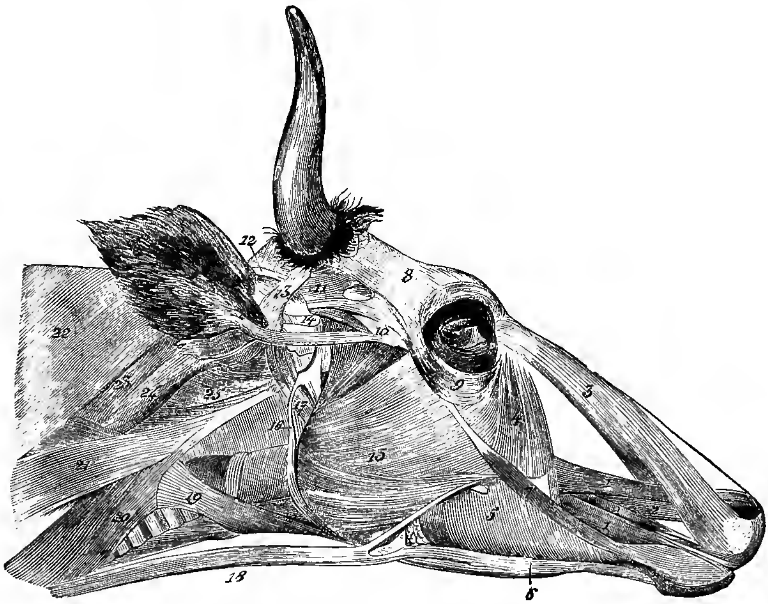
The *middle anterior* (*depressor alæ nasi*) is perfectly developed.

The *mento-labialis* and its suspensory muscle, the *middle posterior*, are scarcely apparent.

2. Palpebral Region.

The *lachrymalis* in the **Ox** is more developed and thicker than in the Horse. Its most anterior fibres glide under the zygomaticus, and are lost on the surface of the buccinator; while

Fig. 172.



SUPERFICIAL MUSCLES OF THE OX'S HEAD.

1, Dilator naris superioris; 1, 1′, accessory fasciculi of the same; 2, dilator naris lateralis; levator labii superioris; 4, lachrymalis; 5, depressor labii inferioris; 6, buccinator confounded with the preceding; 7, zygomatico-labialis; 8, frontal, or cuticularis muscle of the forehead; 9, orbicular muscle of the eyelids; 10, zygomaticus; 11, attollens maximus; 12, scutiform cartilage; 13, external scuto-auricularis; 14, mastoid process; 15, masseter; 16, stylo-hyoideus; 17, digastricus; 18, sterno-maxillary fasciculus belonging to the cervical panniculus; 19, subscapulo-hyoideus; 20, sterno-maxillaris, or mastoideus; 21, anterior branch of the superficial portion of the mastoido-humeralis; 22, superior branch of ditto; 23, deep portion of same muscle; 24, trachelo-atloideus, peculiar to Ruminants and Pachyderms; 25, great anterior straight muscle of the head.

the most posterior pass above the aponeurotic tendon of the zygomaticus and become confounded with the panniculus. This muscle unites, above, with the orbicularis palpebrarum in a more intimate manner than in the Horse, so that it is almost impossible to define the limits of the two (Fig. 172, 4). The *lachrymalis* is absent in the **Pig**.

3. Masseteric or Temporo-maxillary Region.

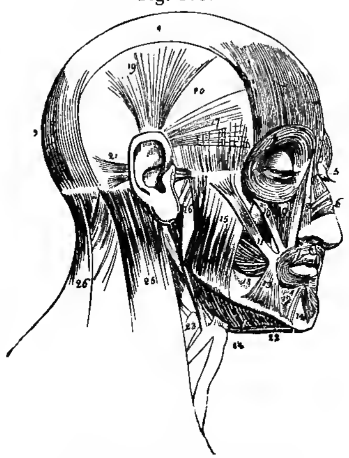
In **Ruminants**, the *masseter* and *temporalis* are not so large as in Solipeds. In the **Carnivora**, however, they offer a remarkable development. The origin of the *pterygoideus* *internus* in **Ruminants** is nearer the middle line than in the Horse. Its obliquity is also greater, and the movements of diduction it gives the lower jaw are more extensive. In all the animals, other than Solipeds, the *stylo-maxillaris* fasciculus of the *digastricus* is entirely absent, and the muscle has only a single belly extending directly from the occipital to the maxillary bone. In the **Ox** is found a small square muscle, formed of transverse fibres, which unites the two digastric muscles by passing beneath the base of the tongue. This muscle, in contracting, may raise the hyoideal apparatus, and in this way supplement the tendon of the digastricus and the inferior ring of the stylo-hyoideus.

4. Hyoideal Region.

The two fleshy planes composing the *mylo-hyoideus* are more distinct in **Ruminants** than in the Horse. The *stylo-hyoideus* of these animals commences by a long thin tendon. The muscle has no ring for the passage of the digastricus. a feature observed in all the domesticated animals except Solipeds.

In the **Carnivora,** the *stylo-hyoideus*, formed by a narrow, very thin, and pale fleshy band, commences on the mastoid portion of the temporal bone by a small tendon; the *kerato hyoideus* is remarkable for its relatively considerable volume; the *occipito-styloideus* and the *hyoideus transversus* are absent.

Fig. 173.



MUSCLES OF THE HUMAN HEAD (SUPERFICIAL LAYER).

1, Frontal portion of the occipito-frontalis; 2, its occipital portion; 3, its aponeurosis; 4, orbicularis palpebrarum; 5, pyramidalis nasi; 6, compressor nasi; 7, orbicularis oris; 8, levator labii superioris alæque nasi; 9, levator labii superioris proprius; 10, zygomaticus minor; 11, zygomaticus major; 12, depressor labii inferioris; 13, depressor anguli oris; 14, levator labii inferioris; 15, superficial portion of masseter; 16, its deep portion; 17, attrahens aurem; 18, buccinator; 19, attollens aurem; 20, temporal fascia covering temporal muscle; 21, retrahens aurem; 22, anterior belly of the digastricus, with tendon passing through pulley; 23, stylo-hyoid muscle; 24, mylo-hyoideus; 25, upper part of sterno-mastoid; 26, upper part of trapezius—the muscle between 25 and 26 is the splenius.

Comparison of the Muscles of the Human Head with those of the Domesticated Animals.

In **Man,** there are described as *muscles of the head*, the *epicranial muscles. muscles of the face*, and those of the *lower jaw*. The *hyoid* and *digastric muscles* are reckoned in the region of the neck. Here they will be placed in the region of the head.

1. Epicranial Muscles.

The middle portion of the human cranium is covered by an aponeurosis that adheres closely to the hairy scalp, but glides easily on the surface of the bones. To the circumference of this epicranial aponeurosis are attached four muscles, which move it. One of them, attached behind to the superior occipital curved line, is named the *occipital muscle;* another, fixed in front of the forehead, is called the *frontal muscle;* the other two, double and lateral, are inserted on the face of the temporal bone or the external ear, and are designated *auricular muscles.* These epicranial muscles move the scalp forwards, backwards, and sideways.

2. Muscles of the Face.

These are fourteen in number, ten of which are found in the domesticated animals. We commence by describing these common muscles (Fig. 170).

1. The *orbicularis oris*, which has a fasciculus that passes to the skin from the columna of the nose; this fasciculus is termed the depressor of the columna, or moustache muscle (*naso labialis*).

2. The *buccinator*, corresponding to the buccinator of animals. Besides its office in mastication, it takes an important part in the blowing of wind instruments.

3. The *superficial elevator of the wing of the nose and the upper lip.* It resembles the levator labii superioris, descends from the orbital margin of the supermaxilla, passes along the wing of the nose, and is lost in the upper lip.

4. The *deep elevator of the wing of the nose and the upper lip*, the analogue of which is found in the dilator naris lateralis.

5. The *zygomaticus*, the presence of which is constant in all species.

6. The *small zygomaticus*, represented in the Horse by only the small oblique fasciculus sometimes found beneath the zygomaticus.

The small zygomaticus and the two elevators of the lips are lachrymal muscles; by their simultaneous contraction they express discontent and melancholy. The zygomaticus, on the contrary, is the muscle of laughter; it draws the commissures of the lips outwards.

7. The *caninus*, or dilator naris lateralis of animals, is attached beneath the infra-orbital foramen, and terminates in the skin of the upper lip.

8. The *risorius of Santorini.*

9. The *muscle of the chin* (*mento-labialis*).

10. The *myrtiformis*, or middle anterior of Bourgelat.

The other facial muscles of Man, whose analogues it is difficult or impossible to find in animals, are:—

11. The *triangularis of the lips*, which is inserted into the anterior face of the inferior maxilla, and is carried upwards to the commissure of the lips. By its contraction it gives the face an expression of melancholy or contempt.

12. The *quadratus menti*, which, after been attached to the maxilla within the mental foramen, passes upwards on the skin of the lower lip, which it depresses, and thus contributes to the expression of fear or dismay.

13. The *transversalis nasi* (*compressor nasi*), a muscle which is fixed into the supermaxilla and on the bridge of the nose, where it is confounded with the opposite muscle.

14. The *dilator of the ala of the nostril*, a very small triangular fasciculus applied to the external part of the nostril, which, by contracting, it elevates.

3. Muscles of the Lower Jaw.

There is nothing remarkable to be noted in the *masseter*, *temporal*, or *pterygoid* muscles. The upper belly of the *digastricus* is not attached directly to the inferior maxilla, as it is in Solipeds.

4. Hyoideal Muscles.

These are only three in number:—

1. The *mylo-hyoideus.*

2. The *stylo-hyoideus*, which commences at the styloid process of the temporal bone, and shows a ring for the tendon of the digastricus.

3. The *genio-hyoideus.*

We do not find in Man the occipito-styloideus, kerato-hyoideus, or the hyoideus-transversus.

Axillary Region.

This comprises two muscles, pairs, placed beneath the sternum, in the axilla which terminate on the anterior limb. These are the *superficial* and *deep pectorals.*[1]

Preparation.—1. Place the animal in the first position. 2. Unfasten one of the forelimbs, and allow it to hang, so as to separate it from the opposite one. 3. Remove the skin with care, and dissect, on the side corresponding to the detached limb, the two muscles which form the superficial pectoral. 4. Prepare the deep pectoral on the opposite side. To do this, remove the panniculus cautiously, so as not to injure the muscle about to be examined; divide the superficial pectoral transversely, and turn back the cut portions to the right and left; divide also the mastoido-humeralis and cervical trapezius near their insertion into the limb, and reflect them upon the neck.

1. Superficial Pectoral (Pectoralis Anticus and Transversus) (Figs. 174, 9, 10; 175, 3).

Synonyms.—Muscle common to the arm and forearm—*Bourgelat.* Pectoralis magnus of Man. (Percivall and Leyh describe three pectorals, others four; but, as will be seen in this work, the two pectorals are each divided into two portions, which, for practical purposes, agrees with those who describe four. This muscle is the *Pectoralis transversus* of Percivall. Leyh

[1] For a justification of the employment of these new denominations, see the note at p. 230.

divides this muscle into two portions, which he designates the *sterno-radialis* and *small sterno-humeralis.*)

Situation—Composition.—This muscle is situated between the two anterior limbs, occupies the inferior surface of the chest, and is formed by two portions which adhere closely to each other, but are yet perfectly distinct. Following the example of Girard, we will describe these as two particular muscles by the names of *sterno-humeralis*, and *sterno-aponeuroticus.*

A. STERNO-HUMERALIS (PECTORALIS ANTICUS).—*Form—Structure.*—This is a short, bulky muscle, flattened above and below, contracted at its termination, and composed almost entirely of thick parallel fibres.

Direction and Attachments.—It commences on the anterior appendage and the inferior border of the sternum, and is directed obliquely backwards, downwards, and inwards, to reach the anterior ridge of the humerus, where it terminates by an aponeurosis common to it, the mastoido humeralis, and the sterno-aponeuroticus.

Relations.—Externally, to the skin, from which it is separated by connective tissue, and to the inferior extremity of the cervical panniculus; internally, to the sterno-aponeuroticus and sterno-prescapularis. Its anterior border forms, with the mastoido-humeralis, a triangular space occupied by the subcutaneous, or "plate," vein of the arm.

Action.—It acts principally as an adductor of the anterior limb.

B. STERNO-APONEUROTICUS (PECTORALIS TRANSVERSUS).—*Form—Structure—Direction—Attachments.*—A very wide, thin, and pale quadrilateral muscle formed of parallel fleshy fibres, which arise from the entire inferior border of the sternum, to pass at first outwards, then downwards, and terminate in the following manner: the anterior fibres go to the aponeurosis which attaches the mastoido-humeralis and pectoralis anticus to the anterior ridge of the humerus; the posterior fibres are also continued by a very thin fascia, which is spread inside the limb to the external face of the antibrachial aponeurosis.

Relations.—By its superficial face, with the skin, which adheres intimately to it by means of dense connective tissue, and with the pectoralis anticus, which covers its anterior border. By its deep face, with the two portions of the other pectoral, the flexor brachii, and the long extensor of the forearm; it also responds, by this face, to the antibrachial aponeurosis and the subcutaneous vein of the forearm, which it maintains applied against that aponeurosis.

Action.—It is an adductor of the anterior limb, and a tensor of the antibrachial aponeurosis.

2. DEEP PECTORAL (PECTORALIS MAGNUS AND PARVUS) (Figs. 174, 11, 13; 175, 1).

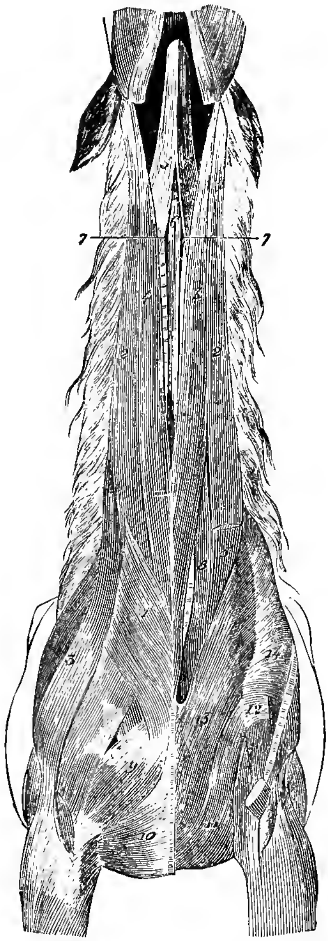
Synonym.—The pectoralis parvus of Man.

Volume—Situation—Composition.—An enormous muscle, situated beneath the thorax, and composed, like the preceding, of two perfectly distinct portions, described by Girard as two muscles, and designated by him as the *sterno-trochineus* and *sterno-prescapularis.*

A. STERNO-TROCHINEUS.—Pectoralis magnus of (Percivall, Rigot, and) Bourgelat. (The *great sterno-humeralis* of Leyh.)

Volume—Extent.—This muscle, the largest of the two, is considerable in volume. Extending from the ninth or tenth rib to the upper extremity of the arm, it at first lies beneath and against the abdomen, then beneath the chest, and at last is comprised between the walls of the latter cavity and the internal face of the anterior limb.

Fig. 174.



MUSCLES OF THE AXILLARY AND CERVICAL REGIONS.

1, Portion of the cervical panniculus; 2, anterior portion of the mastoido-humeralis; 3, posterior portion of ditto; 4, sterno-maxillaris; 5, sub-scapulo-hyoideus; 6, 7, sterno-thyro-hyoideus; 8, scalenus; 9, pectoralis anticus; 10, pectoralis transversus; 11, pectoralis magnus; 12, portion of the fascia enveloping the coraco-radialis, receiving part of the fibres of the pectoralis magnus; 13, pectoralis parvus; 14, its terminal aponeurosis.

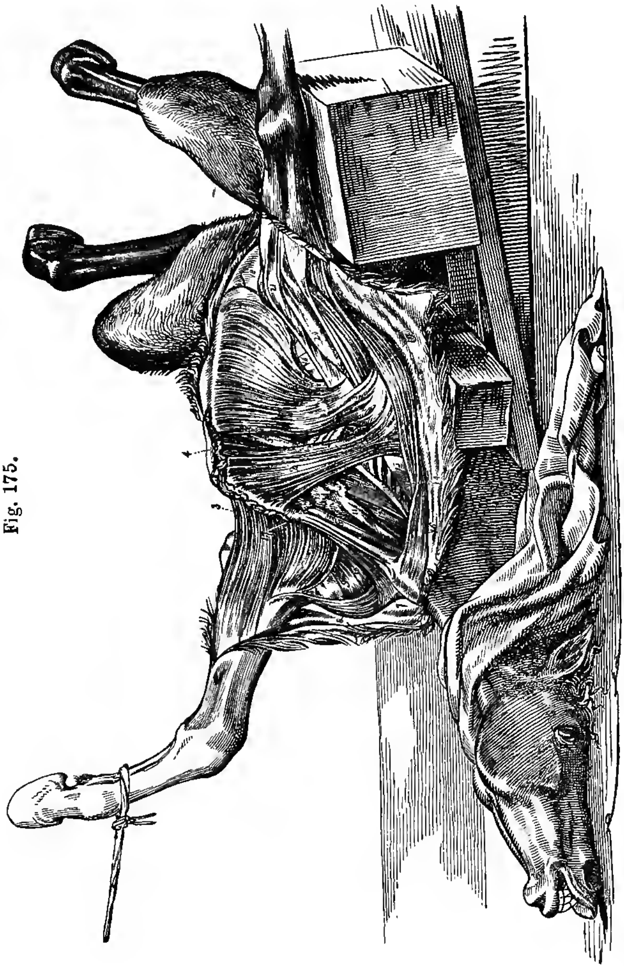
Form.—It is thin and flat above and below in its posterior third, thicker and depressed from side to side in its middle third, and narrow and prismatic in its anterior third. Its general form may be compared to that of a somewhat irregular triangle, elongated from before to behind, which would have a very short posterior border, a longer internal or inferior border, and an external or superior, still more extensive.

Structure.—It is entirely composed of thick, parallel, fleshy fasciculi, all of which leave the posterior or internal border of the muscle to gain its narrow or anterior extremity. These fasciculi, as they approach the superior border, become longer, and those which proceed from the posterior border commence by aponeurotic fibres. Unfrequent intersections of fibrous tissue exist towards the anterior extremity of the muscle.

Attachments.—It originates: 1. From the tunica abdominalis by the aponeurotic fasciculi of its posterior border. 2. By its internal border, from the posterior two-thirds of the inferior border of the sternum. It terminates, by its anterior extremity, on the internal tubercle at the head of the humerus, the tendon of origin of the coraco-humeralis, and the fascia enveloping the coraco-radialis. Through the medium of this fascia, it is inserted into the external lip of the bicipital groove formed by the external trochanter, and is united to the two terminal branches of the supra-spinatus muscles (see Figs. 174, 12; 181, 5).

Relations.—Its deep face, which is successively superior and internal, covers the external oblique and the straight muscle of the abdomen, the serratus magnus, lateralis-sterni, and pectoralis parvus, as well as some thoraco-muscular nerves; all these relations are maintained by means of a loose and abundant connective tissue. Its superior face, which alternately looks downwards and outwards, responds: to the skin, from which it is separated by a slight cellulo-fibrous fascia; to the pectoralis transversus; and to the muscles, vessels, and nerves of the inner aspect of the arm, through the medium of the sub-brachial aponeurosis of the panniculus and a considerable quantity of connective tissue. Its upper border adheres in an intimate manner to the last-named muscle, and is bordered by the spur (external thoracic) vein. The large vascular trunks which leave the chest to reach the anterior limb, pass above its anterior extremity, in crossing its direction.

Fig. 175.



AXILLARY AND THORACIC MUSCLES.

1, Deep pectoral, or pectoralis magnus, with 2, the pectoralis parvus 3, superficial pectoral, or pectoralis transversus, including the sterno-aponeuroticus and sterno-humeralis; 4, their attachment to the sternum; 5, lateralis sterni, or transversalis of the ribs; 6, sterno-maxillaris; 7, 16, panniculus; 8, 19, levator humeri, or mastoido-humeralis; 9, 10, outer attachments of the deep pectoral muscle; 11, 12, sterno-thyro-hyoideus; 13, inferior scalenus; 14, superior scalenus; 15, rhomboideus; 17, point of sternum; 18, intercostal muscle; 18', abdomen; 20, subscapularis; 21, nlna.

Action.—It pulls the whole limb backwards, in pressing on the angle of the shoulder.

B. Sterno-prescapularis.—(The *pectoralis parvus* of Percivall and Bourgelat.)—*Form—Situation—Direction.*—A long prismatic muscle, contracted at its two extremities, situated in front of the preceding, arising from the sternum, directed forwards and outwards towards the scapulo-humeral angle, and afterwards reflected upwards and backwards on the anterior border of the shoulder, which it follows to near the cervical angle of the scapula.

Structure and Attachments.—It is formed of very large fleshy fasciculi, analogous to those of the pectoralis magnus, which originate, by their inferior extremities, from the sides of the sternal keel and the cartilages of the first three or four ribs. They follow the direction of the muscle, and terminate, one above the other, on a short aponeurosis which covers the supra-spinatus, and is confounded with the external aponeurosis of the scapula (Fig. 174, 14).

Relations.—In its axillary portion, this muscle responds, inwardly, to the lateralis sterni, the first sternal cartilages, and the corresponding intercostal muscles; outwards, to the pectoralis magnus and transversus. In its prescapular portion, it is in relation, outwardly, with the mastoido-humeralis and trapezius; inwardly, with the subscapulo-hyoideus, the scalenus, and the angularis of the scapula; behind, with the supra-spinatus, which is separated from it by the external scapular aponeurosis.

Action.—This muscle is a congener of the pectoralis magnus, and pulls the scapula backwards and downwards. It is also a tensor of the scapular aponeurosis.

Differential Characters in the Muscles of the Axillary Region in the other Animals.

With regard to the *pectoralis anticus* and *transversus*, it is remarked that in the **Ox**, **Sheep**, and **Pig**, the former is small and less distinct from the latter than in Solipeds; and that in the **Dog** and **Cat**, the latter is very thin and narrow.

In the **Ox**, the *pectoralis parvus* is scarcely distinct from the *pectoralis magnus*, and which does not extend beyond the inferior extremity of the supra-spinatus. In the **Sheep**, this muscle is quite confounded with the *pectoralis magnus*. In the **Pig**, the *pectoralis parvus* resembles that of the Horse. Its inferior extremity only covers the first chrondo-sternal articulation; the superior extremity is more voluminous. With regard to the *pectoralis magnus*, it terminates on the summit of the external trochanter, after detaching a short branch to the tendon of the coraco-humeralis. The *pectoralis parvus* of the **Dog** is very feeble, and terminates with the principal muscle on the humerus.

Costal Region.

In each costal region we find fifty-three muscles, which concur, more or less directly, in the respiratory movements. These muscles are: 1. The *serratus magnus*. 2. Seventeen *external intercostals*. 3. Seventeen *internal intercostals*. 4. Seventeen *levatores costarum*. 5. The *triangularis sterni*.[1]

Preparation.—1. Place the subject in the second position. 2. Remove the fore limb and all the muscles attaching it to the trunk, by sawing through the scapula as shown in Fig. 162, in order to expose the serratus magnus; finish the dissection by taking away all the yellow fibrous tissue which covers its posterior dentations. 3. Study the external intercostals and the levatores costarum, after removing the great oblique muscle of the abdomen, the serrati muscles, the transversalis costarum, and the longissimus dorsi. 4. Excise some external intercostals in order to show the corresponding internal ones. 5. The triangularis sterni is dissected on another portion, which is obtained in separating the sternum from the thorax, by sawing through the sternal ribs a little above their inferior extremity.

1. Serratus Magnus (Fig. 162, 15).

Synonyms.—Costo-subscapularis—*Girard.* Posterior portion of the serratus magnus of Bourgelat. (A portion of Percivall's *serratus magnus.*)

Form—Situation.—A very wide muscle, disposed like a fan, split up into

[1] Veterinary anatomists describe in this region a muscle which they designate the *costo-sternalis, lateralis sterni*, or *transversalis costarum*, but we consider it a fasciculus detached from the rectus abdominis (see *Inferior Abdominal Region*).

digitations at its inferior border, applied against the thoracic walls, and partly concealed by the shoulder.

Structure.—It is composed of divergent fleshy fibres, all of which converge towards the superior extremity of the scapula, and are covered by a very strong aponeurosis that gradually diminishes from above to below, and only adheres to the muscle in its inferior part.

Attachments.—1. To the external face of the eight sternal ribs. 2. To the anterior triangular surface of the internal face of the scapula, behind the angularis, with which it is confounded. 3. To the whole extent of the posterior triangular surface of that bone.

On reaching the scapula, the aponeurosis separates from the fleshy fibres, and is inserted alone into the fibrous plane which covers the muscular fasciculi of the subscapularis.

Relations.—Outwardly, and through the medium of an abundant supply of connective tissue, which facilitates the play of the limb against the lateral wall of the thorax, to the subscapularis, supra-spinatus, adductor of the arm, latissimus dorsi, and the mass of olecranian muscles; inwardly, to the first seven external intercostals, to the sides of the sternum, and to the anterior small serratus. Its four posterior digitations cross the first five of the great oblique muscle of the abdomen, and are covered by a prolongation of the abdominal tunic.

Action.—With that of the opposite side, this muscle constitutes a vast brace or girth on which the thorax rests when the animal is supported on its anterior limbs; it therefore acts, in relation to the trunk, as a suspensory ligament. When it contracts, its fixed point being the thoracic walls, it pulls the superior extremity of the scapula downward and backward, and causes this portion of the limb to perform a swinging movement which carries the inferior angle upwards and forwards. If the limb is the fixed point, then it raises the thorax between the two anterior limbs, and assists in the respiratory movements by elevating the ribs.

2. External Intercostals (Figs. 161, 162).

Situation—Form.—These muscles fill the spaces between the ribs, but do not descend beyond their inferior extremities; they, therefore, do not occupy the intervals between the cartilages. They are flattened, fleshy bands, gradually diminishing in thickness from above to below.

Structure—Attachments.—Each external intercostal muscle is composed of a series of muscular fasciculi, intermixed with numerous aponeurotic fibres, both of which pass obliquely backwards and downwards, from the posterior border of the preceding to the external face of the succeeding rib.

Relations.—Outwardly, to the different muscles applied against the thoracic walls; inwardly, to the internal intercostals.

3. Internal Intercostals (Fig. 163, 16).

These are placed at the internal face of the preceding, which they exactly repeat with regard to their general form, but from which they differ in the following points:—

1. Very thick between the costal cartilages, these muscles are reduced at the upper part of the intercostal spaces to a thin aponeurotic layer, supported only by some fleshy fibres. They, therefore, gradually diminish in thickness from below upwards.

2. Their fasciculi are less tendinous than those of the external intercostals, and are carried obliquely forward and downward, from the anterior border of the posterior rib to the posterior border and internal face of the rib in front; so that the fibres of the external and internal intercostals cross each other like the letter X.

3. Outwardly, they respond to the external intercostals; inwardly, to the costal pleura.

Action of the intercostal muscles.—The function of these muscles has been for a long time, and is even now, much discussed; and it may be said that there were never, perhaps, more diverse or contrary opinions given on any subject than on this. Bérard, who has summed up the elements of the discussion with the greatest judgment, considers the external intercostals as inspiratory muscles, and the internal ones also as inspiratory by those fasciculi which occupy the spaces between the costal cartilages; the remainder, the majority, are expiratory.

4. Levatores Costarum.

Synonyms.—Transverso-costales—*Girard.*

Small, flat, triangular, muscular, and tendinous fasciculi, constituting, it might be said, the heads of the external intercostals, from which they are scarcely distinguishable in the first and last costal intervals.

They arise from the transverse processes of the dorsal vertebræ, and are directed backwards and outwards, gradually expanding, to terminate on the external face of the one or two ribs which succeed their fixed insertion. Outwardly, they are in contact with the *longissimus dorsi;* inwardly, with the external intercostals.

The *levatores costarum* draw the ribs forward, and are consequently inspiratory muscles.

5. Triangularis Sterni.

Synonyms.—Sternalis—*Bourgelat.* Sterno-costalis—*Girard.* (The *sterno-costales* of Percivall, and *sterno-costalis* of *Leyh.*)

Form—Situation.—This muscle, flattened above and below, elongated from before to behind, and dentated at its external or superior border, is situated in the thoracic cavity, above the sternum and the cartilages of the true ribs.

Attachments.—It is fixed, by its internal border, on the superior face of the sternum, to the ligamentous cord which circumscribes it outwardly. It has its movable insertion on the cartilages of the sternal ribs, the first excepted, by means of digitations from its external border.

Structure.—It is formed of strongly aponeurotic muscular fasciculi, which are directed from the internal to the external border.

Relations.—Inwardly, with the pleura; outwardly, with the cartilages to which it is attached, the internal intercostals, and the internal thoracic vein and artery.

Action.—The triangularis of the sternum concurs in expiration, by depressing the costal cartilages. (Leyh asserts that if the fixed point be the sternum, this muscle pulls the ribs forwards, and so widens the thorax; but if the fixed point is the ribs, the sternum will be raised and the thoracic space diminished.)

Differential Characters in the Muscles of the Costal Region in the other Animals.

The muscles of the costal region cannot be the same in number in all the domesticated animals; the intercostals and levatores costarum, for instance, must vary in number with that of the ribs. Beyond this, the differences are slight. In the **Ox**, the *serratus magnus* is very extensive, and the portion which passes to the posterior triangular surface of the scapula is readily distinguished from the anterior by its diminished thickness, the larger proportion of aponeurotic fibres it contains, and the flattened tendon by means of which it is inserted. In the **Pig,** it is remarked that the internal intercostals are prolonged—maintaining a certain thickness—to near the vertebral spine.

Comparison of the Thoracic Muscles of Man with those of the Domesticated Animals.

The muscles of the axillary and costal regions and the diaphragm, are named the *thoracic muscles* in Man.

The *pectoral muscles* are distinguished into great and small. The *pectoralis magnus* corresponds to the pectoralis anticus and transversus of the Horse. It is attached, on one side, to the inner two-thirds of the clavicle, the anterior face of the sternum, and the cartilages of the first six ribs; on the other, to the anterior border of the bicipital groove, and, by a fibrous expansion, to the aponeurosis of the arm. The costal fasciculi are distinctly separated from the clavicular and sternal fasciculi.

The *small pectoral,* which corresponds to the pectoralis magnus and parvus, is inserted, on the one part, into the external face of the third, fourth, and fifth ribs; on the other part, by a tendon to the anterior border of the coracoid process.

In Man, there is found a muscle which does not exist in animals; this is the *subclavius,* a very slender fasciculus situated beneath the clavicle, and attached to the cartilage of the first rib and the external portion of the lower face of the clavicle (see Fig 164, 5).

The *serratus magnus* does not show any distinct aponeurosis on its surface; it arises from the eight first ribs, and its digitations are grouped into three principal fasciculi.

Lastly, in Man the *internal intercostals* are prolonged to the vertebral column by small muscles, named *intra-costals.*

INFERIOR ABDOMINAL REGION.

The lateral and inferior walls of the abdominal cavity are formed by a wide musculo-aponeurotic envelope, which rests, by its periphery, on the sternum, ribs, lumbar vertebræ, ilium, lumbo-iliac aponeurosis, and the pubis. This envelope is concave on its superior surface, and results from the assemblage of four pairs of large membraneous muscles arranged in superposed layers. Reckoning them from without inwards, these are designated the *great*, or *external oblique*, the *small*, or *internal oblique*, the *great straight*, and the *transverse* muscle. Covered outwardly by an expansion of yellow fibrous tissue—the *tunica abdominalis*—and separated from those of the opposite side by the *linea alba*—a medium raphé extending from the sternum to the pubis—these muscles support the intestinal mass, and by their relaxation or contraction adapt themselves to the variations in volume which these viscera may experience.

Preparation.—After placing the animal in the first position, a wide opening is to be made in the pectoral cavity by the ablation of a certain number of ribs, which should be divided inferiorly, above the costal attachments of the great oblique muscle. The heart and lungs are removed; then an incision is made in the diaphragm, to allow the digestive viscera contained in the abdominal cavity to be taken away. It is not absolutely necessary, however, to empty that cavity, and if its contents be allowed to remain, several punctures should be made in the large intestine to prevent the accumulation of gas, and the too great distension of the abdominal parietes.

These preliminary precautions having been adopted, then proceed in the following manner:—

1. Remove the skin from this region, and with it the panniculus carnosus, in order to study the external surface of the abdominal tunic. 2. The dissection of the great oblique muscle is accomplished by removing the yellow fibrous envelope from the fleshy portion of the muscle, together with the sterno-trochineus. The inguinal ring should be exposed by the ablation of the dartos muscle, the sheath and penis, or the mammæ. 3. On the opposite side, the small oblique is uncovered by excising the great oblique, leaving, however, that portion of the aponeurosis which is mixed up with that of the first muscle. 4. The latter having been studied, dissect the great straight muscle of the abdomen on the same side, in separating from the white line, by a longitudinal incision, the aponeurosis common to the two oblique muscles, dividing this aponeurosis and the fleshy portion of the internal oblique by another incision extending transversely from the umbilicus to the middle of the lumbar region, and laying back one of the musculo-aponeurotic sections on the thigh, the other on the ribs. 5. The transverse muscle is dissected on the same side as the external oblique has been. To expose it, nothing more is necessary than to make two incisions similar to the foregoing, but including the two oblique and the straight muscle, throwing back the two portions as above. 6. Lastly, open the entire abdominal cavity by cutting through the transverse muscle in the same way; then study the muscular digitations of that muscle, the internal orifice of the inguinal canal, and the layer reflected from the aponeurosis of the great oblique muscle.

1. Abdominal Tunic (Tunica Abdominalis, Tunica Elastica).

The vast expansion of yellow elastic fibrous tissue spread over the two external oblique muscles of the abdomen is so named.

Very thick towards the prepubic tendon of the abdominal muscles and in the vicinity of the linea alba, this expansion gradually thins as it approaches the sternum, and disappears near the abdominal insertion of the pectoralis magnus. It also diminishes in thickness as it extends from the linea alba; and when it reaches the fleshy portion of the great oblique muscle it becomes reduced to an extremely thin layer, the fasciculi of which separate more and more from one another, until they completely disappear. Anteriorly, however, it is seen to be prolonged on each side to the posterior digitations of the serratus magnus. Posteriorly, it furnishes some bundles of fibres, which are detached from the surface of the common tendon, and are carried between the thighs to be lost on the internal crural muscles.

The abdominal tunic is covered by the skin and panniculus carnosus, from which it is separated by an abundance of connective tissue. In the male, its external surface gives attachment to the suspensory ligaments of the prepuce, and to the dartos; and in the female, to the elastic capsule which envelops each mammary gland. By its internal face, it closely adheres to the aponeurosis of the great oblique muscle; though it is easily separated from the fleshy portion. It is traversed by several openings, which afford passage to the subcutaneous vessels and nerves of the abdominal region.

Use.—The abdominal tunic acts as an immense elastic girth or bandage, which aids the muscles in sustaining the weight of the intestines. As the digestive organs increase in volume, this tunic increases in thickness.

In the **Pig**, **Dog**, and **Cat**, it is reduced to a simple cellulo-aponeurotic layer, owing to the stomach and intestines in these animals exercising but a small amount of pressure on the abdominal parietes.

2. White Line (Linea Alba).

The white line (*linea alba*) is a fibrous cord comprised between the internal border of the two great straight muscles, and is considered as being formed by the intercrossing, on the median line, of the aponeuroses belonging to the oblique and transverse muscles. Attached, in front, to the inferior surface of the xiphoid appendage, this cord is confounded, behind, with a large tendon, the *prepubic* or *common tendon of the abdominal muscles*, which is fixed to the anterior border of the pubis (Figs. 140, A ; 176, 10). This tendon, covered by the abdominal tunic, contributes to form the internal commissure of the inguinal ring, and gives origin to the pubio-femoral ligament.

Towards the union of its posterior third with its two anterior thirds, the white line widens, so as to form a lozenge-shaped space, in the centre of which is found the remains of the umbilicus and the unbilical cord (Fig. 147, O).

3. Great Oblique, or External Oblique of the Abdomen (Obliquus Abdominis Externus) (Figs. 162, 18 ; 176, 1).

Synonyms. Costo-abdominalis—*Girard.*

Situation—Composition.—This muscle, the largest and the most superficial of the four, is situated on the side and floor of the abdomen, and is composed of a fleshy and an aponeurotic portion.

Form, Structure, and Attachments of the fleshy portion.—This is composed of fibres directed obliquely downwards and backwards, and presents itself as a wide muscular band, narrower before than behind, applied to the inferior surface of the last thirteen or fourteen ribs. Its superior border is concave, and attached : 1. To the external surface of the ribs just mentioned by as many slightly aponeurotic digitations, the first four of which cross the dentations of the great serratus. 2. To the aponeurosis of the latissimus dorsi, from the last rib to the external angle of the ilium (Fig. 162, 18). Its inferior border, convex and sinuous, is continuous with the aponeurosis ; it descends, in front, to the cartilaginous circle of the false ribs, which it projects beyond posteriorly, increasing in this as it nears the lumbar region.

Form, Structure, and Attachments of the Aponeurosis.—This is narrow and thin in front, wide and thick behind, of a triangular form, and composed of white, nacrous-looking fibres passing in the same direction as the fibres of the fleshy portion, with the inferior border of which it is continuous by its external border. Its internal border is inserted into the white line and the prepubic tendon ; and its posterior border, extending from the external angle of the ilium to the anterior border of the pubis, responds to the plicature of the flank, embraces the corresponding crural muscles, and establishes the line of demarcation between the trunk and the abdominal limb.

The aponeurosis of the great oblique gives rise, at its posterior border, to two very remarkable fibrous layers, which appear to be produced by the doubling of this aponeurosis. One of these layers descends on the internal muscles of the thigh to constitute the *crural aponeurosis* (Fig. 176, 4) ; while the other is reflected upwards and forwards, to enter the abdominal cavity. This reflected layer of the great oblique aponeurosis is named the *crural arch* (*ligament of Poupart* or *Fallopius*) (Fig. 165, B).

Near the prepubic tendon of the abdominal muscles, and immediately before its division into two layers, the aponeurosis of the external oblique is pierced by a large oval aperture (the *external abdominal ring*) (Fig. 176, 5), the inferior orifice of the canal through which passes the cord of the testicle in the male, and the mammary vessels in the female. This channel has been named the *inguinal canal.*

The description of the femoral aponeurosis, the crural arch, and the inguinal ring—a necessary complement of the great oblique muscle—will be given hereafter.

Relations of the Great Oblique Muscle.—Externally, to the pectoralis magnus and the abdominal tunic, which latter separates it from the skin and the panniculus. By its deep face, it is related to the ribs, into which it is inserted, as well as with their cartilages, the corresponding intercostal muscles, the small oblique, and the rectus abdominis. The latter even appears to be attached, through the anterior moiety of its external border, to the fleshy portion of the great oblique, by means of a slight layer of yellow elastic tissue, which covers, to a small extent, the deep face of the two muscles.

Action.—The external oblique, in contracting, compresses the abdominal viscera, flexes the vertebral spine, and acts as an expiratory muscle. (By its compression on the abdominal viscera, it concurs in the acts of defecation, micturation, and parturition.)

INTERNAL CRURAL APONEUROSIS.—This fibrous layer descends from the plicature of the flank on to the patella and the inner surface of the leg. Outwardly, it is confounded with the aponeurosis of the fascia lata; inwardly, it degenerates into connective tissue. It covers the long adductor of the leg, part of the short adductor, the vastus internus, and the crural vessels at their exit from the abdominal cavity.

CRURAL ARCH.—As already mentioned, this is the reflected layer of the great oblique aponeurosis, and is also named the *ligament of Fallopius* and *Poupart's ligament.* It is a wide, flat band, attached by its extremities to the external angle of the ilium and the anterior border of the pubis. Its anterior face (Fig. 165, B) forms, inwardly, the posterior wall of the inguinal canal; it gives attachment, outwardly, to the posterior fibres of the small oblique muscle. Its posterior face, applied against the superior extremity of the patellar muscles, the long adductor of the leg, the pectineus, and the crural vessels on their leaving the abdomen, embraces all these parts as in a vast arch, and from this peculiarity it derives its name. Its superior border is inserted, for its external half, into the lumbo-iliac aponeurosis. In its middle part it is much thinner, and is prolonged to the external surface of the long adductor muscle of the leg and the iliac fascia, to be at last mixed up with the latter. Within the pectineal insertion of the small psoas muscle, it forms the anterior margin of the *crural ring:* a triangular orifice circumscribed on the other side by the anterior border of the pubis, the iliacus, and the long adductor of the leg, and through which pass the crural vessels as they leave the abdomen by the crural arch.[1] The inferior border is continuous with the femoral aponeurosis and that of the great oblique muscle.

INGUINAL CANAL.—This is an infundibuliform canal, compressed laterally, through which the spermatic cord and external pudic artery pass from the abdomen in the male, and the external mammary vessels in the female.

Situated on the side of the prepubic region, in an oblique direction downwards, backwards, and inwards, and measuring from two to two and a half inches in length, this canal lies between the crural arch, which constitutes its posterior

[1] This orifice is covered by a very thin aponeurotic layer, which is prolonged, above, on the crural vessels, behind, into the pelvic cavity, and which appears to be continuous, inferiorly, with the upper border of Poupart's ligament. This layer is perhaps only a dependency of the subperitoneal aponeurosis; and if so, it represents the only vestige of the *fascia transversalis* it has been possible to discover in Solipeds.

wall, and the fleshy portion of the small oblique muscle, which forms the anterior wall.

Its *inferior* (*external*) or *cutaneous orifice*, also named the *inguinal* or *external abdominal ring*, is much larger than the superior (*internal*). Pierced in the aponeurosis of the great oblique, in the angle formed by the union of the internal border with the posterior border of the aponeurosis, this opening is oval in form, directed obliquely backwards and inwards, which permits it to be described as having *two lips* or *pillars*, and *two extremities* or *commissures*.

The *pillars*, distinguished into *anterior* and *posterior*, are composed of the arciform fibres from the aponeurosis of the great oblique muscle.

The *commissures*, *internal* and *external*, result from the union of the two pillars at their extremities. The internal is limited by the prepubic tendon of the abdominal muscles.

The *superior* (*internal*) or *peritoneal orifice* of the inguinal canal, is situated in front of, and directly opposite to, the crural ring. It is a simple dilatable slit, comprised, like the canal itself, between the crural arch and the small oblique muscle. Not well defined at its extremities, this opening includes the neck of the vaginal sheath.

4. Small or Internal Oblique Muscle of the Abdomen (Obliquus Abdominis Internus) (Figs. 163, 17′; 176, 6).

Synonyms.—Ilio abdominalis—*Girard.*

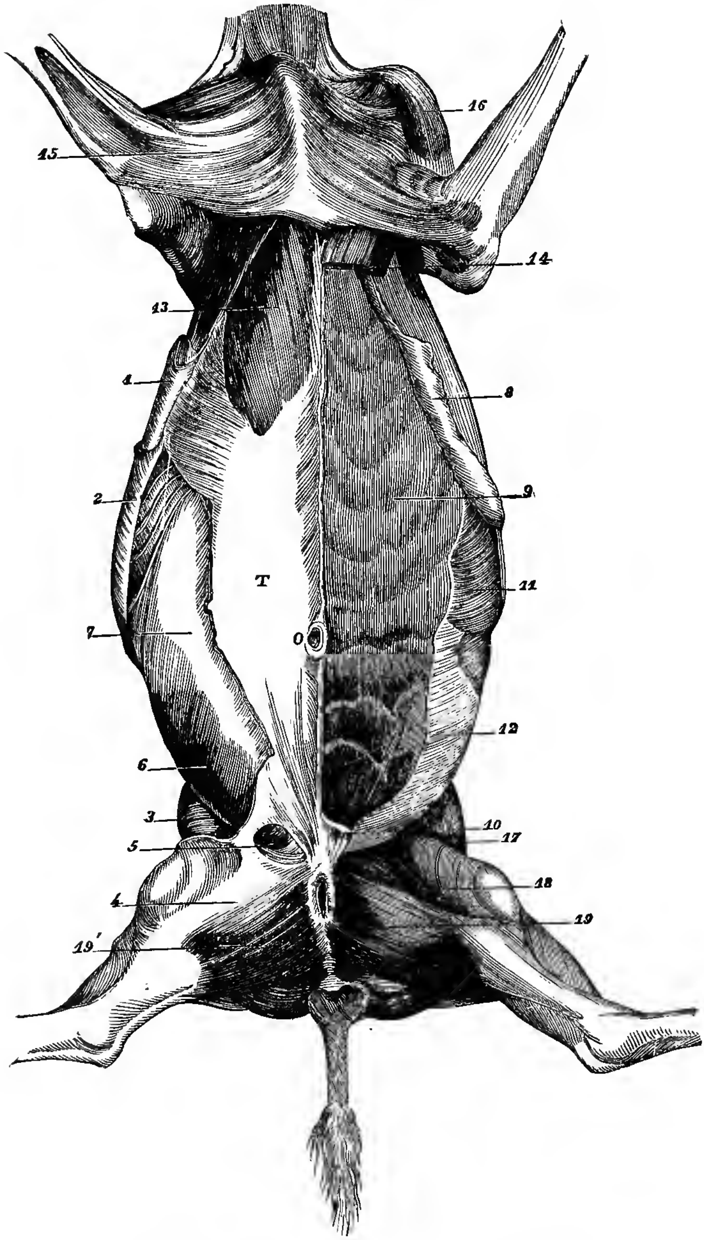
Situation—Composition.—Situated beneath the preceding, which exactly covers it, this muscle is, like it, composed of a fleshy and aponeurotic portion.

Form, Structure, Position, and Attachments of the muscular portion.—The muscular portion is very thick, triangular, and flabelliform, and occupies the region of the flank. Its superior border is united, by a thick, yellow, elastic production, to the aponeurosis of the latissimus dorsi, and a peculiar small muscle, named by the Germans the *retractor costæ* (*retractor of the last rib*), which we consider as a dependency of the small oblique muscle. Its posterior border is slightly raised, and lies against the crural arch, from which it separates, inwardly, to form the inguinal canal. Its anterior and inferior border is convex, irregular, and thinner than the other portions of the muscle, and is continuous with the aponeurosis. All the fibres entering into the composition of this muscular portion are spread like a fan, and leave the external angle of the ilium and the external fourth of the crural arch, to be directed, the posterior fibres backwards and inwards, the middle fibres downwards, and the anterior fibres forwards to reach the antero-inferior border of the muscle.

Form, Structure, and Attachments of the Aponeurosis.—The aponeurosis is irregularly triangular, and formed of nacrous-looking fibres, which are directed like the muscular fibres, and cross in X fashion the aponeurotic fibres of the external oblique. It succeeds the antero-inferior border of the muscular portion, and is separated, superiorly, into several digitations which reach the internal face of the last asternal cartilages. Throughout the whole extent of its internal border it is fixed to the white line.

Relations.—Externally, with the external oblique. The aponeuroses of the two muscles, which are merely superposed outwardly, are blended inwardly in so intimate a manner, that it might be considered their respective fasciculi were

Fig. 176.



MUSCLES OF THE INFERIOR ABDOMINAL REGION (ASS).

T, Abdominal tunic; O, umbilicus. 1, Panniculus carnosus detached from the tunica abdominalis and turned to the left; 2, 3, portion of the great oblique turned over to the left; 4, femoral aponeurosis; 5, external abdominal ring; 6, muscular portion of the small oblique muscle; 7, aponeurosis of ditto; 8, strips of the tunica abdominalis and aponeuroses of the great and small oblique muscles turned over to the right; 9, rectus abdominis; 10, prepubic tendon; 11, muscular portion of the transversalis abdominis; 12, aponeuroses of that muscle; 13, left pectoralis magnus; 14, section of right ditto; 15, pectoralis anticus and transversus; 16, inferior extremity of the mastoido-humeralis; 17, muscle of the *fascia lata;* 18, long adductor of the leg; 19, 19′, short adductors of the leg.

woven into each other. The small oblique covers the rectus and transversalis abdominis.

Action.—This muscle, a congener of the preceding, compresses the abdominal viscera, depresses the last ribs, and causes the flexion—either direct or lateral—of the vertebral column.

The retractor muscle of the last rib.—This small muscle, flattened on each side and triangular in form, originates by aponeurotic fibres from the summits of the first two or three transverse processes of the lumbar region. It terminates on the posterior border of the last rib. Covered by the last digitation of the posterior serratus and by the great oblique, it covers in turn the transversalis abdominis. In contracting, it draws the last rib backwards, and fixes it in that position, in order to permit the expiratory action of the internal intercostal muscles. It therefore plays the same part, in regard to these muscles, that the scalenus does to the external intercostal muscles (Fig. 162, 17).

5. Great Straight Muscle of the Abdomen (Rectus Abdominis) (Figs. 162, 20; 176, 9).

Synonym.—Sterno-pubialis—*Girard.*

Situation—Extent—Form—Structure.—This is a wide and powerful muscular band, extending from the sternum to the pubis, included between the aponeurosis of the internal oblique and that of the transversalis muscles, narrower at its extremities than in its middle, and divided by numerous transverse and zig-zag fibrous intersections. These strongly adhere to the aponeurosis of the small oblique muscle, are nearer to each other, and more distinct, in front than behind, and are produced by small tendons which are placed at certain distances on the course of the muscular fasciculi, making it somewhat of a polygastric muscle.

Attachments.—In front: 1. To the prolonging cartilages of the last four sternal and the first asternal ribs. 2. To the inferior face of the sternum. Outwardly, by the anterior moiety of its external border, to the internal face of the great oblique. Behind, to the anterior border of the pubis, through the medium of the common tendon, which is a direct continuation of the rectus abdominis.

Relations.—By its inferior face, and in front, with the pectoralis magnus and great oblique; for the remainder of its extent, with the aponeurosis of the small oblique. By its superior face, with the transversalis muscle and the cartilages of several ribs. By its internal border, with the white line, which separates it from the opposite muscle.

Action.—It draws the thorax backwards, and compresses the abdominal viscera. It is also the principal flexor of the spine. (Leyh, remarking that it shares in the functions of the preceding muscles, adds that it draws the pelvis forwards during copulation.)

6. Transverse Muscle of the Abdomen (Transversalis Abdominis) (Figs. 163, 18; 176, 12, 12).

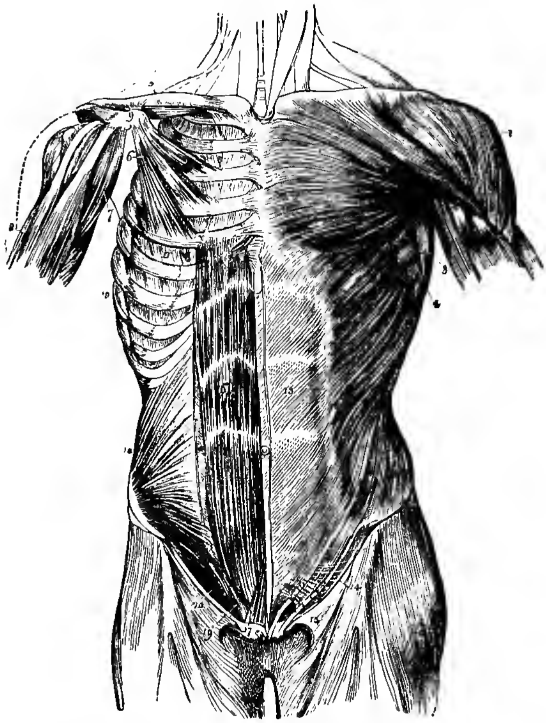
Synonyms.—Lumbo-abdominalis—*Girard.* (The *costo-abdominalis internus* of Leyh.)

Situation—Composition.—This muscle is situated immediately outside the peritoneum, and forms the deep layer of the abdominal parietes. It is muscular outwardly, and aponeurotic for the remainder of its extent.

Form, Structure, and Attachments of the muscular portion.—It presents a band elongated from before to behind, extending from the sternum to the transverse processes of the last lumbar vertebræ, following in its course the direction of the cartilages of the ribs, and composed of parallel fibres passing from one border to the other.

Its superior border, concave, is attached: 1. To the internal surface of the asternal ribs by digitations placed opposite those of the diaphragm, but the

Fig. 177.



MUSCLES OF THE ANTERIOR ASPECT OF THE BODY OF MAN. ON THE LEFT SIDE THE SUPERFICIAL LAYER IS SEEN; ON THE RIGHT, THE DEEPER LAYER.

1, Pectoralis major; 2, deltoid; 3, anterior border of the latissimus dorsi; 4, serratus magnus; 5, subclavius, right side; 6, pectoralis minor; 7, coraco-brachialis; 8, biceps, with its two heads; 9, coracoid process of the scapula; 10, serratus magnus, right side; 11, external intercostal muscle of the fifth intercostal space; 12, external oblique; 13, its aponeurosis with the linea alba; 14, Poupart's ligament; 15, external abdominal ring; 16, rectus muscle of right side; 17, pyramidalis muscle; 18, internal oblique; 19, conjoined tendon of internal oblique muscle and Poupart's ligament.

majority of which do not mix with them. 2. To the extremity of the transverse processes of the lumbar region by a thin fibrous layer. Its inferior border is convex, and continuous with the aponeurosis.

Form, Structure, and Attachments of the aponeurosis.—This is triangular-shaped, with the base behind, and with its fibres running in a direction transverse to the median line. Closely laid one against another in front, these fibres separate behind, and form only a very thin and incomplete layer.

By its external border, the aponeurosis is joined to the inferior margin of the muscular portion. Its internal border is fixed to the xiphoid cartilage and the white line. Its posterior border, badly defined, appears to join the crural arch only on its outer aspect.

Relations.—Outwards, with the inferior extremity of the asternal ribs and their cartilages, with the rectus abdominis, the small oblique, and the depressor muscle of the last rib; inwardly, with the peritoneum, from which it is separated by the subperitoneal aponeurosis—an extremely fibrous layer which, in Man and some animals, becomes much thickened towards the crural arch, where it forms adhesions. It has been described, in human anatomy, as the *fascia transversalis.*

Action.—It compresses the abdominal viscera when it contracts, and presses them against the vertebral column.

Differential Characters in the Muscles of the Abdominal Region in the other Animals.

A. **Ruminants.**—The development of the *tunica abdominalis* is in proportion to the volume of the digestive viscera. This membrane is, therefore, very wide and thick in Ruminants.

The *obliquus externus* has no femoral aponeurosis; its aponeurosis is therefore entirely reflected in the abdominal cavity. The *inguinal canal* is very short; its upper orifice is very narrow, and it is situated near where the two portions of the long adductor of the leg unite (Goubaux); its inferior opening is very elongated from before to behind, and without to within.

The muscular portion of the *small oblique* occupies the entire space comprised between the posterior border of the last rib, the extremity of the transverse processes of the lumbar vertebræ, and the external angle of the ilium. The small *retractor of the last rib* is not distinct from the principal muscle. The *rectus abdominis* is wide behind, with tendinous intersections more marked at its superior than its inferior face; the aponeurosis of the *transversalis* is much thicker and more resisting than in Solipeds.

The *prepubic tendon* of the abdominal muscles is large, and attached to the inner face of the short adductors of the leg by two ligamentous bands; this attachment depresses the lower part of the abdominal wall, and therefore it is that, in Ruminants, there is a concave depression in front of the pubis.

B. **Pig** and **Carnivora.**—The *tunica abdominalis* is reduced to an insignificant layer. The *external oblique* is remarkable for the enormous development of its muscular portion and the narrowness of its aponeurosis. The *internal oblique* resembles that of Ruminants.

Comparison of the Abdominal Muscles of Man with those of Animals.

With the exception of some slight differences, the abdominal muscles of Man resemble those of the smaller animals. The *tunica abdominalis* does not exist, but is represented by a layer of connective tissue which separates the skin from the aponeurosis of the *obliquus externus.* The muscular portion of this muscle has no attachment to the aponeurosis of the great dorsal.

The aponeurosis of the *obliquus internus* is divided into two layers at the external border of the rectus muscle; the anterior is consolidated with the external oblique, and passes in front of the rectus; the posterior is united to the transversalis, and passes behind that muscle.

The aponeurosis of the *transversalis* is divided into two layers, only one of which remains behind the rectus; this is named the *semilunar fold of Douglas.*

The *rectus* offers three transverse fibrous intersections in its length (*lineæ transversæ*). At its upper extremity, it divides into three branches: the internal is attached to the xiphoid appendage and the cartilage of the seventh rib; the middle, to that of the sixth rib; the external, to the cartilage of the fifth rib.

"To the rectus is annexed a small triangular muscle, the *pyramidalis*, which is not found in animals. This muscle is about 2⅓ inches long; is sometimes absent; most developed in children; is attached by its base to the pubis, between the spine and the symphysis; and by its summit is continuous with a tendon which is lost in the white line, and constitutes, with that of the opposite side, a fibrous cord which may be followed to the umbilicus" (*Beaunis and Bouchard*).

Lastly, at the inner aspect of all the abdominal muscles, beneath the peritoneum, is a fibrous layer—the *fascia transversalis*. This fascia is not distinctly limited upwards or outwards: below, it is fixed to the crural arch, in the vicinity of the inguinal canal, and sends a layer to the surface of the cord spermatic.

Diaphragmatic Region.

This is composed of a single muscle, the *diaphragm*.

Diaphragm.

Preparation.—Place the subject in the first position; open the abdomen and remove the viscera it contains, as well as the large vascular trunks lying upon the sublumbar region; detach the peritoneum from the fleshy portion of the muscle, in order to show the digitations of the latter more distinctly, taking care not to allow the air to enter the thoracic cavity, as it would destroy the tense and concave form of the diaphragm.

Situation—Direction.—The diaphragm is a vast musculo-aponeurotic partition, separating the thoracic from the abdominal cavity, between which it is placed in an oblique direction downwards and forwards.

Form.—It is flattened before and behind, elliptical, wider above than below, concave posteriorly, and convex anteriorly.

Structure.—This muscle comprises: 1. A central aponeurotic portion designated the *phrenic centre*, which is incompletely divided into two *leaflets* by the *pillars* or *crura*—fleshy columns which descend from the sublumbar region. 2. A peripheral or circumferential portion, forming a wide muscular band around the phrenic centre.

The *phrenic centre* (also named the *speculum Helmontii*, or mirror of Helmont) is composed of white, glistening, radiating fibres which, originating from the pillars, extend in every direction to join the muscular fibres of the peripheral portion. It is pierced, in its right leaflet, by a large opening for the posterior vena cava (*foramen dextrum*).

The *crura* or *pillars* are two in number—a *right* and *left*. The *right crus* or *pillar*, the most considerable, is a very thick, fleshy fasciculus which commences under the loins by a strong tendon, united to the inferior common vertebral ligament. It descends to the phrenic centre, to which it gives a heart-shaped appearance. Near its inferior extremity, it presents an opening for the passage of the œsophagus and pneumogastric nerves, in the abdominal cavity (*foramen sinistrum*). The *left pillar* is a small triangular fasciculus, partly separated from the preceding by an orifice (*hiatus aorticus*) for the transmission of the posterior aorta, vena azygos, and thoracic duct. It also arises from the sublumbar region by a tendon, which is confounded with that of its congener.

The *peripheral muscular portion* is continuous, by its concentric border, with the central aponeurosis. Its eccentric border is divided into dentations. Above, and on the left side, it nearly always joins the left pillar; but on the right side it stops at a certain distance from the corresponding pillar, so that towards this point the phrenic centre is not enveloped by the peripheral portion, and is in contact with the sublumbar region.

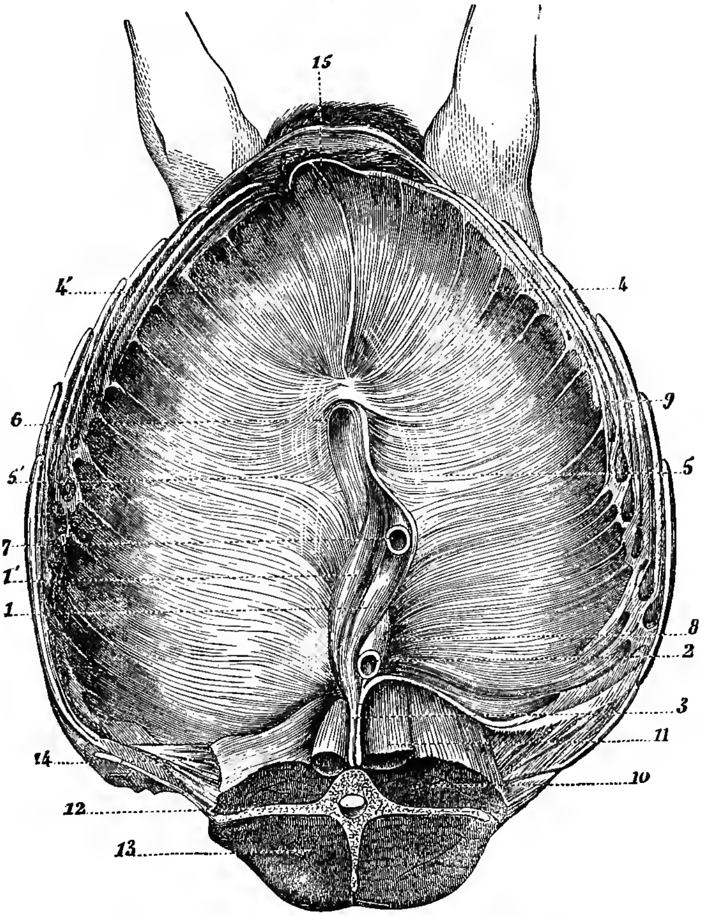
Attachments.—1. To the bodies of the lumbar vertebræ by the tendons of its two pillars, which tendons are confounded with the inferior common vertebral ligament. 2. By the external contour of its muscular portion, to the superior face of the xiphoid cartilage[1] and the inner face of the last twelve ribs, near

[1] This sternal fasciculus sometimes shows a depression, in which the serous membranes of the abdomen and thorax come into contact. If this fosette enlarges, it is converted into an opening through which hernia of the intestine into the cavity of the chest may take place.

their inferior extremities or cartilages. The digitations forming the last insertions do not intercross, in Solipeds, with those of the transversalis muscle of the abdomen, being separated by an interval which is wider behind than before.

Relations.—Anteriorly, it is covered by the pleura, and responds, mediately, to the base of the lung. The posterior aspect, covered by the peritoneum, is in contact with the greater part of the viscera contained in the abdominal cavity—

Fig. 178.



DIAPHRAGM OF THE HORSE (POSTERIOR FACE).

1, 1′, The two portions of the right crus or pillar; 2, left crus or pillar; 3, tendons of the pillars; 4, 4′, peripheral muscular portion; 5, left leaflet of the aponeurotic portion; 5, 5′, right leaflet of the same; 6, posterior vena cava; 7, œsophagus passing through the opening in the right pillar; 8, posterior aorta between the two pillars; 9, cartilaginous circle of the ribs; 10, 11, section of the psoas muscle; 12, section of a lumbar vertebra; 13, section of the common mass; 14, retractor muscle of the last rib; 15, xiphoid appendage of the sternum.

the stomach, colon, spleen, and liver; the latter is even attached to this surface for a portion of its extent.

On each side of the pillars, the circumference of the muscle forms an arch which passes over the great and small psoas muscles.

Action.—The diaphragm, in contracting, tends to become an inclined plane; its central portion is carried backwards, and the antero-posterior diameter of the chest is increased. It is, therefore, essentially an inspiratory muscle. It may also raise the ribs by making the mass of abdominal viscera its fixed point; it then acts as a reflected muscle, to which these viscera serve as a pulley. (The diaphragm also aids the other abdominal muscles in expulsive efforts, and, when affected with irregular spasmodic contractions, produces the peculiar phenomenon in Man and some of the lower animals, known as hiccough.)

Differential Characters of the Diaphragm in the other Animals.

In the **Ox**, the pillars of the diaphragm are very long and voluminous. "The attachments of the muscular portion are much farther distant from the cartilaginous circle than in the Horse, particularly at the superior part; this disposition explains the innocuousness of puncture of the paunch in the middle of the *last intercostal space;* for in the Horse, when the instrument is passed through this part, it penetrates the thorax" (*communicated to M. Lecoq by M. Tabourin*).

In the **Sheep**, we have not remarked that the costal attachments were more forward than in the Horse.

Rigot erroneously states that, in the **Pig** and **Dog**, the œsophagus passes between the two pillars of the diaphragm; on several occasions we have convinced ourselves that this tube traverses the right pillar, as in the other animals.

Comparison of the Diaphragm of Man with that of Animals.

In the human diaphragm, the aponeurotic portion is divided into three leaflets, which has caused it to be termed the *aponeurotic trefoil.* Between the middle and right leaflet is the orifice through which the inferior vena cava passes. The openings for the passage of the œsophagus and the aorta are situated between the two pillars. There are frequently met with, in Man, one or two small accessory pillars, separated from the large pillars by an aperture that affords a passage, on the right side, to the vena azygos and the sympathetic nerve, and on the left side, to one of the lumbar veins and the other sympathetic nerve.

The peripheric muscular portion always joins, posteriorly, the central muscular portion.

Article II.—Muscles of the Anterior Limbs.

These are divided into four principal groups: the muscles of the shoulder, arm, forearm, and foot.

Muscles of the Shoulder.

These muscles are grouped around the scapula, and all act upon the arm, which they extend, flex, abduct, adduct, etc. They form two regions: an *external* or *supra-scapular*, and an *internal* or *subscapular*.

A. External Scapular Region.

This comprises four muscles: the *long abductor of the arm* (*teres externus*), the *short abductor* (*postea spinatus minor*, or *teres minor*), the *supra-spinatus*, and *infra-spinatus*. These muscles are applied to the external surface of the scapula, and are covered by an aponeurotic layer.

Preparation of the external scapular region.—Separate the limb from the trunk; remove the trapezius and mastoido-humeralis, to expose the external surface of the aponeurosis; take away, also, the small pectoral muscle, after studying its mode of insertion into this fascia.

This being accomplished, next remove the latter muscle to show the supra-spinatus, the infra-spinatus, and long abductor muscle of the arm; leaving only the strip which attaches the anterior portion of the latter to the tuberosity of the scapular spine.

To study the short abductor muscle, it is only necessary to cut the long abductor and supra-spinatus across, and to throw back the sections: an operation requiring some care, because of the intimate adherence of the short abductor to the infra-spinatus.

1. External Scapular Aponeurosis.

This aponeurosis, to which the pectoralis parvus and long adductor of the arm act as tensors, gives origin, by its internal face, to several septa which penetrate between the scapular muscles, and form around them more or less complete contentive sheaths. Its external face is separated from the skin by the panniculus carnosus, trapezius, mastoido-humeralis, and the aponeurotic fascia which unites the last two muscles. It is continuous, in front, with the thin fibrous expansion extended over the internal scapular muscles; behind and downwards, it is prolonged over the muscles of the arm and insensibly degenerates into connective tissues; above, it is attached to the fibro-cartilaginous prolongation of the scapula.

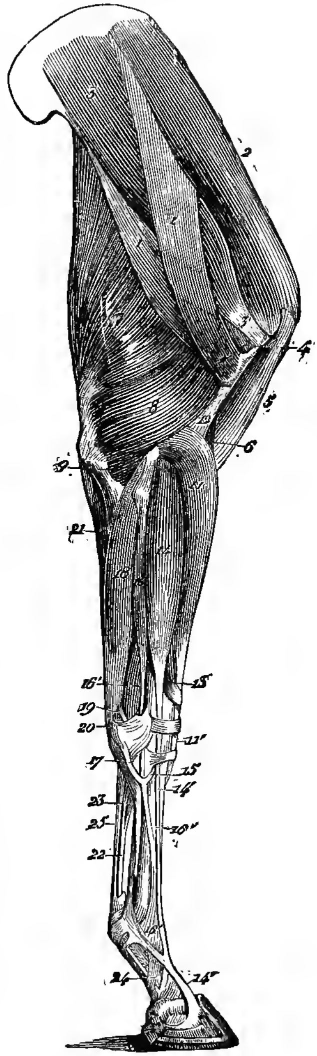
2. Long Abductor of the Arm (Teres Externus), or Scapular Portion of the Deltoid (Fig. 179, 1, 1).

Synonyms. — Scapulo-humeralis magnus — *Girard.* (*Teres major—Percivall. Great scapulotrochiterius—Leyh.*)

Situation—Composition—Form—Direction.— This muscle is situated beneath the scapular aponeurosis, behind the infra-spinatus, and is composed of two portions placed one above the other, separated by a superficial interspace. The posterior portion, the most considerable, is elongated from above to below, bulging in its middle, narrow at its extremities, plane on its external and convex on its internal surface. It accompanies the posterior border of the infra-spinatus, and is lodged in a depression in the large extensor muscle of the forearm.

The anterior portion, much shorter than the preceding, extends over the infra-spinatus and short abductor, by slightly crossing the direction

Fig. 179.



EXTERNAL MUSCLES OF THE RIGHT ANTERIOR LIMB.

1, 1, Long abductor of the arm; 1′, its humeral insertion; 2, supra-spinatus; 3, infra-spinatus; 3′, its tendon of insertion; 4, short abductor of the arm; 5, biceps; 6, anterior brachialis; 7, large extensor of the forearm; 8, short extensor of the forearm; 9, anconeus; 11, anterior extensor of the metacarpus; 11′, its tendon; 12, aponeurosis separating that muscle from the anterior brachialis; 13, oblique extensor of the metacarpus; 14, anterior extensor of the phalanges; 14′, its principal tendon; 15, the small tendinous branch it furnishes to the lateral extensor; 16, lateral extensor of the phalanges; 16′, its tendon; 17, the fibrous band it receives from the carpus; 18, external flexor of the metacarpus; 19, its metacarpal tendon; 20, its supra-carpal tendon; ulnar portion of the perforans; 22, tendon of the perforans; 23, its carpal ligament; 24, its reinforcing phalangeal sheath; 25, tendon of the perforatus.

of these two muscles. Thick inferiorly, this portion diminishes considerably towards its superior extremity.

Structure and Attachments.—The first portion is generally paler than the second, and is composed of longitudinal fleshy fibres deeply intersected by tendinous strips. It takes its origin, by its superior extremity, from the dorsal angle of the scapula. The anterior portion is deeper-coloured and more tendinous than the other. Its superior extremity, included within two fibrous folds resulting from the duplicature of the scapular aponeurosis, is fixed, through the medium of these, to the tuberosity of the scapular spine.

These two muscular bodies unite inferiorly, and terminate together on the deltoid imprint or crest by tendinous and muscular fasciculi.

Relations.—Outwardly, to the scapular aponeurosis, with which it may be said to form one body; inwardly, to the infra-spinatus, the short abductor of the arm, and the large and short extensors of the forearm.

Action.—It gives a very marked abduction movement to the humerus, and also makes it pivot outwards. It acts, besides, as a flexor of that bone, when its action is combined with that of the adductor of the arm. It should also be considered as a powerful tensor of the scapular aponeurosis.

3. Short Abductor of the Arm (Postea Spinatus Minor), or Teres Minor (Fig. 128, 2, 3).

Synonyms.—Scapulo-humeralis minor—*Girard.* (*Scapulo-trochiterius, medium and parvum —Leyh.*)

Volume—Situation—Direction.—A small elongated muscle, situated below the preceding and the subspinatus, along the posterior border of the scapula, the direction of which it follows.

Form—Structure.—In its inferior half it is prismatic, muscular, divided by fibrous intersections, and easily separated into several irregular fasciculi. In its superior half it is flattened, entirely tendinous, and split into several digitations, the longest of which are behind.

Attachments.—It originates: 1. Through the medium of its tendinous digitations, from the posterior border of the scapula and the linear imprints in the infra-spinous fossa. 2. From the small tubercle situated on the external side of the margin of the glenoid cavity, by a short tendon. It terminates on the humerus, between the crest of the external tubercle and the deltoid imprint.

Relations.—Outwardly, with the infra-spinatus and the long abductor; inwardly, with the large extensor of the forearm, the short extensor, and the capsule of the scapulo-humeral articulation.

Action.—Like the preceding, this muscle is an abductor and outward rotator of the humerus.

4. Supra-spinatus (Antea-spinatus) (Figs. 179, 2; 181, 5).

Synonyms.—Supra-acromio-trochiterius—*Girard.* (*Antea spinatus—Percivall. Anterior spinatus—Leyh.*)

Form—Situation.—This muscle is thick and prismatic, stronger below than above, representing a very elongated pyramid, and completely filling, and even projecting beyond, the supra-scapular fossa.

Structure—Attachments.—It is almost entirely formed of fleshy fibres, which are attached, by their superior extremities, to the cartilage of prolongation of the scapula, the inner face of the scapular aponeurosis, the supra-scapular fossa, and the anterior border and cervical angle of the scapula—*fixed insertion.* These fibres, on reaching the inferior extremity of the muscle, form two very thick, short, and slightly tendinous branches, united to each other by the enveloping flexor brachii or biceps aponeurosis. The external branch reaches the summit of the external trochanter of the humerus; the internal is inserted into the corresponding part of the internal trochanter—*movable insertion.*

Relations.—Outwards, with the scapular aponeurosis, to which its fibres adhere in the most intimate manner; inwards, with the scapula and the subscapularis muscle; forwards, with the small pectoral; and behind, with the scapular spine and the infra-spinatus. The two terminal branches cover and embrace the flexor brachii tendon, and the capsule of the scapulo-humeral articulation.

Action.—This muscle is an extensor of the humerus, and a tensor of the enveloping flexor brachii aponeurosis. With regard to the articulation of the shoulder, it plays the part of a powerful ligament—a function it shares with the majority of the other scapular muscles.

5. Infra-spinatus (Postea-spinatus) (Fig. 179, 3, 3′).

Synonym.—Subacromio-trochiterius—*Girard.*

Situation—Form.—Situated, as its name indicates, in the infra-spinatus fossa, this muscle is wide, thin, and flattened on both sides at its superior extremity, thick and prismatic in its middle, and conoid at its inferior extremity, which is terminated by two short branches—an external and internal.

Structure.—The muscular fibres are directed, like the muscle itself, forward and downward; they are deeply mixed with strong aponeurotic layers. Of the two branches in which it terminates inferiorly, the external is the strongest, and is entirely constituted by a powerful tendon; the internal is both muscular and aponeurotic.

Attachments.—All the fleshy fasciculi of this muscle are fixed, either directly, or through the medium of the internal aponeurotic layers: 1. To the whole extent of the infra-spinatus fossa. 2. To the scapular spine and its tuberosity. 3. To the cartilage of prolongation of the scapula. 4. To the internal face of the scapular aponeurosis—*fixed insertion.* The movable insertion of the muscle takes place, on the external tuberosity, by its two terminal branches, the internal passing within the convexity; and the strong tendon constituting the external branch (Fig. 179, 3′) gliding, by means of a synovial bursa, over the surface of this convexity, and attaching itself to the roughened facet which forms the crest of the external tuberosity.

Relations.—It is covered by the anterior portion of the long abductor of the arm, and by the scapular aponeurosis. It covers the scapula, its cartilage, the fixed insertion of the large extensor of the forearm, and the short abductor, which adheres to it in the most intimate manner at its superior or aponeurotic portion. Its anterior border responds to the scapular spine and supra-spinatus muscle; the posterior is bordered by the long abductor of the arm. Its inferior extremity protects, outwardly, the capsule of the scapulo-humeral articulation, and is concealed beneath the mastoido-humeralis.

Action.—The infra-spinatus acts on the humerus as an abductor and outward rotator.

B. Internal Scapular Region.

This is composed of four muscles: three principal—the *subscapularis*, *adductor of the arm* (*teres internus*), and the *flexor brachii*—are situated on the internal face of the scapula, and are covered by a very small fibrous fascia which is formed of some scattered parallel fibres that run in a transverse direction. The fourth, named the *small scapulo-humeralis*, is a very slender fasciculus deeply lodged behind the articulation of the shoulder.

Preparation.—Turn over the limb which has served for the dissection of the preceding region, and remove the slight internal scapular fascia. Be careful to preserve the termination of the latissimus dorsi muscle, in order that its relations and adhesions with the adductor of the arm may be studied; leave also the humeral insertion of the pectoralis magnus, so that its union with the tendon of the coraco-humeralis may be noted; in a word, prepare the region as it is represented in Fig. 181. With regard to the small scapulo-humeral muscle, it ought to be dissected at the same time as the short flexor of the forearm.

1. Subscapularis (Fig. 181, 3).

Synonym.—Subscapulo trochineus—*Girard.*

Situation—Direction—Form.—This muscle, lodged in the subscapular fossa, the name of which it bears, has the same oblique direction as the scapula. It is wider above than below, and divides superiorly into three portions; so that its form exactly repeats that of the excavated surface it covers.

Structure.—The muscular fibres of the subscapularis slightly converge towards its inferior extremity, and all end in a very strong, wide, and short tendon. They are intermixed with deep and superficial tendinous fibres, which singularly increase the tenacity of the muscle; the superficial fibres are spread over the internal surface in glistening, nacrous layers.

Attachments.—The subscapularis has its origin from the whole extent of the fossa of that name. Its movable insertion takes place on the internal tuberosity of the humerus, by means of a voluminous tendon it offers at its inferior extremity. A particular small synovial bursa facilitates the gliding of this tendon over the eminence into which it is inserted.

Relations.—Externally, with the scapula. Its internal face is applied against the serratus magnus, from which it is separated by a thick layer of connective tissue, as well as by the rudimentary fascia covering the three muscles of the internal scapular region in common. Its anterior border, margined by the supra-spinatus, adheres closely to that muscle in its upper two-thirds, and forms with it, by its inferior third, the intermuscular space that lodges the subscapular vessels and nerves. Its posterior border responds to the adductor of the arm, with which it also unites for the greater part of its extent; it is isolated from this muscle, in its inferior third, by the interspace lodging the subscapular vessels and nerves. Its terminal tendon covers the capsule of the scapulo-humeral articulation, which it powerfully binds; it is in part covered by the tendon of origin of the coraco-humeralis muscle, which glides over its surface as on a pulley, by means of a synovial bursa.

Action.—This muscle is principally, and perhaps exclusively, an adductor of the arm. It may be admitted, however, that it rotates the humerus inwards.

2. Adductor of the arm (Teres Internus, or Teres Major) (Fig. 181, 4).

Synonyms.—Subscapulo-humeralis—*Girard.* (*Great scapulo-humeralis—Leyh.*)

Form—Situation—Direction.—A long muscle, flattened on both sides, bulging in its middle, contracted at its extremities, thick at its anterior, and thin at its posterior border. It is situated behind the preceding, in the same oblique direction, and is parallel with the posterior portion of the long abductor, which it appears to repeat in the internal scapular region.

Structure.—It is almost entirely muscular, showing only some tendinous fibres at its external surface and upper extremity. Its inferior extremity is terminated by a flat tendon, which also belongs to the latissimus dorsi, and which has been already described (see p. 260).

Attachments.—It arises from the dorsal angle of the scapula, and the posterior border of the subscapular muscle—*origin;* it passes to the internal tuberosity of the humerus, to be attached by its inferior tendon—*termination.*

Relations.—Outwards, with the aponeurosis of the latissimus dorsi and that of the long extensor of the forearm, which isolates it from the large extensor muscle; inwards, with the serratus magnus, from which it is separated by the fibrous and cellular layers mentioned in the description of the subscapularis. Its inferior extremity covers the short flexor and middle extensor of the forearm; it is covered by the long branch of the coraco-humeralis, and by the vessels and nerves which send their ramifications to the arm, forearm, and foot.

Action.—This muscle adducts the arm, and causes it to rotate inwards. If it contracts at the same time as the long abductor, it directly flexes the humerus.

3. Coraco-humeralis, Coraco-brachialis, or Omo-brachialis (Fig. 181, 10).

Synonym.—Middle scapulo-humeralis—Leyh.

Volume—Situation—Direction.—A small elongated muscle, which appears to belong to the arm rather than the shoulder, as it is situated at the internal face of the humerus, which it slightly crosses. If it is described as in the subscapular region, it is because of its attachments and action, which are, in every respect, analogous to those of the other muscles of the shoulder.

Attachments—Form—Structure.—It commences on the beak of the coracoid process by a small flat tendon, which is at first included between the supra-spinatus and subscapularis, but afterwards leaves the interstice formed by these two muscles, to be inflected and glide over the terminal tendon of the latter. This small tendon is succeeded by two muscular branches—one deep, the other superficial. The first is a wide, thin, and short band, almost entirely muscular, attached to the body of the humerus above the internal tuberosity. The second forms a fleshy body of a certain thickness, flattened on both sides, and strongly aponeurotic; the fasciculi composing it are longer as they are more posterior, and are inserted, by their inferior extremities, into the imprints on the anterior face of the humerus.

Relations.—This muscle is covered by the flexor brachii, and by the pectoralis magnus, which is partly attached to its tendon. It covers the internal insertion of the subscapularis, the humerus, the common tendon of the latissimus dorsi, the adductor of the arm, and a small portion of the short flexor and middle extensor of the forearm. Its posterior border is margined by the vessels and nerves on the inner aspect of the arm. The anterior humeral nerve passes between its two branches, along with an arterial and venous ramification.

Action.—It is an adductor of the arm, and makes it also pivot inwards. Its direction and attachments do not permit it to produce rotation outwards, though it has been stated to do so by several authors.

4. Small Scapulo-humeralis (Scapulo-humeralis Gracilis, Scapulo-humeralis Posticus).

(*Synonyms.*—Not mentioned by Percivall. Leyh, in addition to the above designation, names it the *tensor of the capsular ligament.*)

The scapulo-humeralis gracilis is a very small cylindrical fasciculus, comprised between the large extensor of the forearm and the capsule of the scapulo-humeral articulation ; it derives its origin above the margin of the glenoid cavity of the scapula, and terminates below the head of the humerus by a thin tendon, which insinuates itself between the fibres of the short flexor of the forearm. This muscle appears to be peculiar to Solipeds, and has been regarded by Rigot as intended to raise the capsule of the scapulo-humeral articulation during flexion, so as to prevent its being pinched between the articular surfaces.

Differential Characters in the Muscles of the Shoulder in the other Animals.

The **Carnivora** are the only animals which offer somewhat notable differences in the muscles of the shoulder.

Thus, the *long abductor of the arm*, very developed, has an anterior portion arising directly from the acromion process, and a posterior portion which springs from the whole extent of the scapular spine, by a short aponeurosis. The *supra-spinatus* is considerable, and terminates in a single branch that goes to the great trochanter.

The *infra-spinatus* is not so large as the preceding, and is also undivided at its inferior extremity: it is the inferior branch which is absent.

The *coraco-humeralis* is very short, and is composed of a single fasciculus, which terminates above the humeral insertion of the adductor of the arm.

In the **Pig,** the disposition of this muscle is the same; it is very tendinous.

In the **Camel,** on the external surface of the scapular region is an elastic layer which extends over all the limb, and is worthy of notice. It arises from the borders of the cervical ligament, covers the shoulder and arm, and is thickest behind the scapulo-humeral angle, where the abductors and extensors of the forearm separate. It descends on the forearm in front of the humero-radial articulation, and reaches the lower third of the anterior face of that region, where it divides into two portions. The narrower and thinner of these go to the front of the knee, where it gradually disappears in becoming thinner and lighter-coloured; the largest division passes behind, and joins an equally elastic layer which comes from the inner surface of the olecranian muscles and the elbow; it reaches behind the knee, where it divides into several strips, some of which are fixed into the inner border of the carpus and metacarpus, and others on the flexor tendons of the phalanges, behind the metacarpo-phalangeal articulations.

This very remarkable elastic apparatus tends incessantly to flex the bone of the anterior limb; and to its presence must certainly be attributed the characteristic locomotion of the Camel—jerking and almost passive flexion of the metacarpus on the forearm, and the forearm on the arm.

In the Camel, it is also remarked that the *long abductor of the arm* is entirely muscular, and, superiorly, is only attached to the acromion spine.

Comparison of the Muscles of the Shoulder of Man with those of Animals.

As muscles of the shoulder, there are only described the *deltoid, infra-spinatus, teres minor* and *major*, and the *subscapularis*; the *coraco-brachialis* being included in the region of the arm, while the *small scapulo-humeralis* is absent (see Fig. 180).

The *deltoid*, represented in part by the long abductor of the arm of Solipeds, is a large, triangular, flat muscle, that covers the articulation of the shoulder. Its fibres are inserted into the external third of the anterior border of the clavicle, the external border of the acromion, and the inferior border of the scapular spine for the whole of its width; below, it is attached, through the medium of a tendon, to the deltoid imprint.

By their disposition, the *supra-spinatus*, *infra-spinatus*, and *subscapularis* resemble the muscles of Carnivora. The *teres major*, after establishing relations with the latissimus dorsi, as in Solipeds, is fixed into the inner lip of the bicipital groove.

Muscles of the Arm.

These muscles, grouped around the humerus, are attached to the forearm by their inferior extremities. Those situated in front flex this portion of the limb, while those behind extend it. The first form the *anterior brachial region;* the second, the *posterior brachial region.*

Fig. 180.

MUSCLES OF ANTERIOR ASPECT OF MAN'S UPPER ARM.

1, Coracoid process of scapula; 2, coraco-clavicular ligament (trapezoid), passing upward to clavicle; 3, coraco-acromial ligament, passing to acromion; 4, subscapularis; 5, teres major; 6, coraco-brachialis; 7, biceps; 8, upper end of radius; 9, brachialis anticus; 10, internal head of triceps.

A. Anterior Brachial Region.

This region is composed of only two muscles—the *long* and *short flexors of the forearm.*

1. Long Flexor of the Forearm (Flexor Brachii, or Brachial Biceps) (Figs. 128, 159, 181).

Synonyms.—Coraco-cubitalis, or coraco-radialis, according to *Girard.* (*Scapulo-* or *coraco-radialis—Leyh.*)

Preparation.—Place the limb on its internal face, throw back the brachial insertion of the mastoido-humeralis, pectoralis anticus, and pectoralis transversus, over the external muscles of the forearm; excise, lengthways, the inferior extremity of the supra-spinatus, to show the originating tendon of the muscle. The inferior insertion may be studied with that of the short flexor muscle.

Form—Situation—Direction—Structure.—A long, cylindrical muscle, thick in its middle portion, bifid inferiorly, situated in front of the humerus, in an oblique direction downwards and backwards, tendinous at its two extremities, divided by a great number of strong fibrous intersections, one of which, nearly central and much more considerable than the others, is a very resisting cord that traverses the muscle throughout its length, and becomes continuous with the tendons at its extremities.

Attachments.—This muscle has its origin at the base of the coracoid process by a superior, round, and thick tendon (Fig. 128, 6) that reaches the bicipital groove, on which it is moulded in becoming fibro-cartilaginous, and over which it glides by means of a synovial sac, to be inflected backwards and confounded with the body of the muscle. Its inferior tendon, extremely short and strong, terminates on the superior and internal tuberosity of the radius—the *bicipital tuberosity*—in becoming united to the capsular ligament of the elbow-joint, and insinuating itself beneath the internal ligament of this articulation. At its origin, this tendon gives off a somewhat resisting fibrous band, which is spread over the surface of the anterior extensor of the metacarpus, and is confounded with the antibrachial aponeurosis.

Relations.—It covers an adipose cushion, which separates it from the capsule of the scapulo-humeral articulation, the anterior face of the humerus, the coraco-humeralis, and the articulation of the elbow. It is covered: 1. By the supra-spinatus, between the two branches of which it passes. 2. By a special aponeurotic sheath, the tensor of which is the above-named muscle, with the pectoralis magnus (see Fig. 179, 12, in which this aponeurosis has been partly preserved). This sheath separates the flexor brachii from the mastoido-humeralis, the pectoralis transversus, and from its congener—the short flexor.

Fig. 181.

INTERNAL ASPECT OF LEFT ANTERIOR LIMB.

1, Prolonging cartilage of scapula; 2, inner surface of scapula; 3, subscapularis; 4, adductor of the arm, or teres internus; 5, supra- or antea-spinatus; 6, long extensor of the forearm, or portion of the caput magnum; 7, large extensor of the forearm, the other portion of the caput magnum; 8, middle extensor, or caput medium; 9, humeralis obliquus, or short flexor of the forearm; 10, coraco-humeralis; 11, upper extremity of humerus; 12, coraco-radialis, or flexor brachii; 13, lower extremity of humerus; 14, brachial fascia; 15, anterior extensor of the metacarpus, or extensor metacarpi magnus; 16, belly and aponeurotic termination of the flexor brachii; 17, ulna; 18, oblique flexor of the metacarpus; 19, internal flexor of the metacarpus, or epicondylo-metacarpus; 20, radius; 21, tendon of the oblique extensor; 22, large metacarpal bone; 23, flexor tendons of the foot; 24, suspensory ligament; 25, internal rudimentary metacarpal bone; 26, extensor tendon of the foot; 27, metacarpo-phalangeal sheath; 28, lateral cartilages of the foot; 29, podophyllæ.

Action.—This muscle is a flexor of the forearm, and a tensor of the antibrachial aponeurosis. It acts, besides—through the cord which traverses its entire length—as an inextensible band that mechanically opposes the flexion of the scapulo-humeral angle while the animal is standing, and when the forearm is maintained fixed by the contraction of the humero-olecranian muscles.

2. Short Flexor of the Forearm (Humeralis Obliquus, Brachialis Anticus, Humeralis Externus) (Fig. 128, 12).

Synonyms. — Humero-cubitalis obliquus, or humero-radialis — *Girard.* (*Humero-radialis—Leyh.*)

Preparation.—Lay the limb on its internal face, and remove the abductors of the arm, the infra-spinatus, and the large and short extensors of the forearm, in order to expose the middle and upper extremity of this muscle. Then turn the limb on its external face to dissect the inferior extremity. To study it in all its details, it is a good plan to cut through the internal ligament of the ulnar articulation, and those muscles of the forearm which are attached to the epicondyle.

Form—Structure—Situation—Direction.—This is a very thick muscle, almost entirely fleshy, voluminous in its superior part, and constricted inferiorly. It is lodged in the musculo-spiral groove of the humerus, the direction of which it exactly follows as it turns round the bone to cover, successively, its posterior face, external face, anterior face, and the capsule belonging to the elbow articulation, until it finally reaches the inner side of the radius.

Attachments.—The muscular fibres have their fixed insertion on the posterior face of the humerus, below the articular head. They terminate, inferiorly, on a flat tendon, which they almost entirely cover. This tendon glides in a transverse groove situated on the inner face of the radius, below the bicipital tuberosity, and afterwards passing under the internal ligament of the elbow-joint, it divides into two very short fasciculi ; one of these goes to the radius, and the other to the ulna, where it is mixed up with the bundles of arciform fibres which unite, on the inner side, the two bones of the forearm.

Relations.—We already know the parts this muscle covers. It is covered, inwardly, by the adductor of the arm and the middle extensor of the forearm ; posteriorly and externally, by the large and short extensors of that bone. Its inferior extremity, comprised between the anterior extensor of the metacarpus and the flexor brachii, passes below the antibrachial band of the latter, as under a fibrous bridge.

Action.—It is simply a flexor of the forearm.

B. Posterior Brachial Region.

This is composed of four muscles, which have their movable insertion in common on the summit of the olecranon, and are consequently designated *olecranian muscles.* With reference to their action, they are also designated *extensors of the forearm*, and are distinguished into *long*, *short*, *middle*, and *small.*[1]

The first three of these muscles resemble the *triceps brachialis* (or *triceps extensor cubiti*) of Man—the *large extensor* representing the *long* or *middle portion*, the *short extensor* the *external*, and the *middle extensor* the *internal.* The *small extensor* takes the place of the *anconeus* or *elbow muscle* of some authorities.

Preparation.—The muscles of this region ought to be studied before those of the preceding region. To dissect the large and short extensors, it is necessary to lay the limb on its inner face, remove the slight fibrous layer which covers these two muscles, and raise the abductors of the arm, which in great part conceal their origin. The limb is kept in the same position for the dissection of the small extensor, which is not easily accomplished, as it is almost entirely concealed by the short extensors, which, besides, closely adhere to it. To dissect the long and middle extensors, it suffices to turn the limb on its external surface and cut away the vessels, nerves, and lymphatics which partly cover the latter; care must also be taken to isolate the muscle annexed to the latissimus dorsi.

1. Large Extensor of the Forearm (Caput Magnum), or Long Portion of the Triceps Brachialis (Figs. 179, 7 ; 181, 7).

Synonyms.—Scapulo-olecranius magnus—*Girard.* The long portion of the triceps brachialis of Man. (Portion of the *caput magnum* of the *triceps extensor brachii—Percivall.*)

Volume—Form—Situation.—An enormous, short, and triangular muscle,

[1] In veterinary works, and in preceding editions of this work, there has been described in this region a fifth muscle—the *long extensor of the forearm.* This has now been moved to the region of the back and loins, where it is annexed to the *latissimus dorsi,* because of its relations with that muscle.

occupying, with the short extensor, the space comprised between the posterior border of the scapula and the humerus.

Structure and Attachments.—The fleshy mass constituting this muscle is formed of very thick fasciculi, among which are found some aponeurotic bands. These fasciculi have their origin on the dorsal angle and the axillary border of the scapula, either directly, or through the medium of two strong fibrous layers, between which they are at first included. They are afterwards directed backwards and downwards, and converge towards a thick tendon which occupies the posterior and inferior angle of the triangle represented by this muscle. The tendon terminates by attaching itself to the summit of the olecranon, after receiving a great number of fibres from the short extensor, and after gliding, by means of a synovial capsule, over the eminence which serves for its insertion.

Relations.—The external surface is covered by a thin, fibrous, white-and-yellow layer, which separates it from the panniculus ; it has near the upper border an excavation into which is received the posterior portion of the long abductor. Its internal face responds to the latissimus dorsi, the adductor of the arm, and the long extensor. Its posterior border is margined by the latter muscle ; the superior follows the axillary border of the scapula, and is attached to it to constitute the fixed insertion of the muscle ; the inferior border responds to the short and middle extensors.

Action.—It is an extensor of the forearm.

2. Short Extensor of the Forearm (Caput Medium), or External Portion of the Triceps (Fig. 179, 8).

Synonym.—Humero-olecranius exteruus—*Girard.*

Situation—Direction—Form—Structure.—This muscle is situated between the humerus and the inferior border of the preceding muscle, and is directed obliquely downwards and backwards. It is thick and short, flattened and aponeurotic at its upper extremity, prismatic, and entirely formed of thick parallel muscular fasciculi for the remainder of its extent.

Attachments.—One of its attachments is on the humerus, to the curved line extending from the deltoid ridge to the base of the articular head (see for this line Fig. 62, above 4), by the short aponeurosis of its superior extremity—*fixed insertion ;* the other is to the olecranon, either directly, or through the tendon of the large extensor—*movable insertion.*

Relations.—The prismatic shape of this muscle offers three faces, which respond : externally, to the two abductors of the arm and to a slight fibrous layer continuous ; above, with that which covers the large extensor ; and below, with the antibrachial aponeurosis ; internally, to the small extensor—from which it is difficult to separate it—to the short flexor of the forearm, and to the anterior extensor of the metacarpus ; superiorly, to the large extensor, which closely adheres to it.

Action.—An extensor of the forearm.

3. Middle Extensor of the Forearm (Caput Parvum), or Internal Portion of the Triceps (Fig. 181, 8).

Synonyms.—Humero-olecranius internus—*Girard.* (*Caput parvum—Percivall.*)

Situation—Direction—Form—Structure.—This muscle is situated at the internal face of the humerus, along the inferior border of the large extensor.

It is oblique downwards and backwards, pyriform, enlarged at its superior extremity, contracted inferiorly, where it terminates by two small flat tendons.

Attachments.—It originates, by its superior extremity, from the inner aspect of the humerus, behind and above the tuberosity on its body. One of its terminal tendons is attached to the summit of the olecranon; the other glides over a small convexity on the inner side of that eminence, and goes to be inserted a little lower than the first.

Relations.—Above, with the inferior border of the large extensor; outwards, with the humerus, the short flexor, and short extensor of the forearm; inwards, with the humeral insertion of the latissimus dorsi and the abductor of the arm, the long branch of the flexor brachii, the vessels and nerves on the inner side of the arm, and the long extensor of the forearm.

Action.—An extensor of the forearm.

4. Small Extensor of the Forearm or Anconeus (Fig. 128, 10).

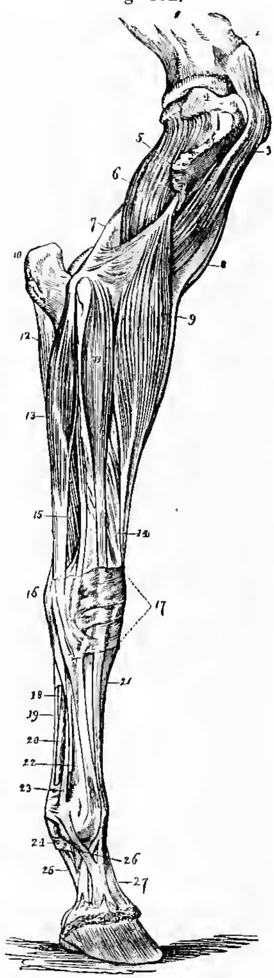
Synonym.—Humero-olecranius minor—*Girard.*

Form—Structure—Situation—Relations.—This is a small, thick, and prismatic muscle, almost entirely fleshy, situated behind the elbow articulation. It is applied against the synovial *cul-de-sac* which ascends into the olecranian fossa, and to which it is strongly attached; it is hidden by the short extensor, from which it is not easily distinguished.

Attachments.—It originates from the margin of the olecranian fossa, chiefly above and outwards. It terminates by being inserted into the anterior and external part of the olecranon.

Action.—This little muscle, a congener of the preceding, raises the articular capsule it covers, and prevents its being pinched between the bony surfaces.

Fig. 182.



DEEP MUSCLES ON THE EXTERNAL ASPECT OF RIGHT ANTERIOR LIMB.

1, Scapula; 2, coracoid process of scapula; 3, flexor brachii; 4, superior extremity of humerus; 5, external tuberosity of humerus; 6, humeralis obliquus; 7, body of humerus; 8, biceps; 9, anterior, or great extensor of the metacarpus; 10, ulna; 11, extensor pedis, or anterior extensor of the phalanges; 12, ulnaris accessorius, or ulnar portion of the perforans; 13, lateral extensor of the metacarpus, or extensor suffraginis; 14, oblique extensor of the metacarpus; 15, flexors of the foot; 16, trapezium; 17, annular ligament; 18, carpal ligament of perforans tendon, 20; 19, perforatus tendon; 21, tendon of anterior extensor of metacarpus; 22, small metacarpal bone; 23, suspensory ligament; 24, lateral band of metacarpo-phalangeal sheath; 25, perforans tendon; 26, branch of the suspensory ligament joining the extensor pedis, 27.

Differential Characters in the Muscles of the Arm in the other Animals.

In all animals, the *long flexor of the forearm*, or *flexor brachii*, is less thick and tendinous than in Solipeds.

In the **Pig, Dog,** and **Cat,** it comports itself in a special manner at its inferior extremity; it is attached at first to the bicipital tuberosity, and also furnishes a small tendinous branch which glides over the inner side of the radius by means of a synovial bursa, and is fixed within the ulna, towards the base of the olecranon.

The *flexor brachii* or *biceps* of the Camel, is manifestly decomposable into two muscular portions, united above in a tendon. The inner portion is the largest and somewhat fusiform, and is attached directly to the radius by its muscular fibres. The other portion, situated external to and in front of the preceding, ends in a bifurcated tendon, one branch of which goes to the bicipital tuberosity; the other, succeeded by a small fleshy fasciculis, joins the body of the anterior extensor of the metacarpus.

The *short flexor of the forearm*, or *humeralis obliquus*, is terminated in the **Pig, Dog,** and **Cat,** by a small tendon which is fixed in the ulna, below the ulnar branch of the flexor brachii.

The *middle extensor of the forearm* and *anconeus* of these animals are remarkable for their volume.

COMPARISON OF THE MUSCLES OF THE ARM OF MAN WITH THOSE OF ANIMALS.

In *Man*, three muscles are situated in front of the humerus—the *biceps, coraco-humeralis*, and the *humeralis obliquus;* behind are found the *triceps brachialis*, and the *anconeus*.

The *biceps*, which corresponds to the flexor brachii of animals, commences on the scapula by two heads, which unite towards the upper part of the humerus. The long portion is detached from the upper part of the rim of the glenoid cavity; the shortest commences from the summit of the coracoid process. The inferior tendon of the biceps gives off, before fixing itself on the bicipital tuberosity, a fibrous layer which is confounded with the antibrachial aponeurosis.

The *coraco-humeralis* has only one fleshy body.

As in the Carnivora and Pig, the *humeralis obliquus* terminates on the ulna, below the coronoid process.

The *triceps brachialis* exactly represents, by its three heads, the large, middle, and short extensors of the forearm of animals (see Fig. 180).

There is nothing particular with regard to the *anconeus*.

Muscles of the Forearm.

These muscles, nine in number, distributed in two regions—anterior and posterior—envelop the bones of the forearm on every side except the internal, where the radius is in mediate contact with the skin. They all terminate on the different sections of the hand or anterior foot, which they flex or extend, and are contained in a common fibrous sheath, which constitutes the *antibrachial aponeurosis*.

Antibrachial Aponeurosis.

This retaining fascia forms a very strong and resisting envelope, which is firmly fixed around the antibrachial muscles by the insertions it has on the bones of the forearm, being attached to the olecranon, the internal aspect of the radius, and to the inferior extremity of that bone, both inwards and outwards.

Its external face is covered by the superficial vessels and nerves, which are separated from the skin by a very thin fibrous layer, more particularly observable on the inner side, where it covers the antibrachial aponeurosis in a very evident manner; it is rendered tense by the pectoralis transversus. Up to the present time, this fibrous layer has not been distinguished from the aponeurosis it covers. The inner face of the latter gives rise to several septa, which penetrate the interstices of the muscles to form around some of them special retention sheaths; it adheres to several of them very intimately. At its upper border, this aponeurosis receives, inwardly, the insertion of the annexed muscle of the latissimus dorsi; in front, the accessory band of the flexor brachii; outwardly, it is continuous with the fascia covering the external face of the olecranian muscles. Inferiorly, it is prolonged around the knee to form the tendinous sheaths of that region.

The antibrachial aponeurosis is madĕ tense by the contraction of the annexed muscle of the latissimus dorsi, and that of the flexor brachii. With reference to the pectoralis transversus, which has hitherto been regarded as intended to play the same part, it can only act on the fascia which covers, externally, the antibrachial aponeurosis.

Preparation of the muscles of the forearm.—The preparation of these muscles is extremely simple, as it suffices to remove the antibrachial aponeurosis and the interstitial cellulo-adipose tissue, to expose and to isolate them from each other. No special recommendations need therefore be given, as a glance at Figs. 179, 181, 182, and 183 will guide the student in his dissection, and supplement the manual details which would be superfluous here.

Nevertheless, as the terminal insertions of some of these muscles are enclosed within the hoof, and as it is indispensable, in order to expose them, to remove this horny case, some explanation will be given as to the manner in which this should be effected, particularly as the apparent difficulty and labour too frequently cause this part to be omitted in the dissecting-rooms.

1. The instruments necessary to remove the hoof are: a scalpel, toe knife, hammer, and a pair of pincers.

2. The limb should be in a vertical position, held by one or two assistants, and the foot placed on a table, stool, or very solid block of wood.

3. Pass the scalpel as deeply as possible around the coronet, to separate the wall of the hoof from the organized tissues.

4. With the knife and hammer, split the wall into four or five pieces by vertical incisions.

5. When the wall is thus divided, it is sufficient to insert the knife under the fragments, and, making it serve as a lever, tear them off; pincers may also be used for this purpose, each of the pieces being twisted from the sole.

6. To remove the sole, the blade of the scalpel should be passed between its upper face and the plantar surface of the third phalanx; afterwards the toe-knife may be inserted in the interval at the bulbs of the frog, so as to slightly raise the external border of the sole. This is then seized by the pincers and pulled off, along with the frog, in a single piece, by a powerful twisting movement, aided by the assistants, who press on the limb in a contrary direction.

A. Anterior Antibrachial Region.

In Solipeds, this region includes four extensor muscles. Two act on the entire foot; these are the *anterior extensor* and the *oblique extensor of the metacarpus.* Two others—the *anterior* and the *lateral extensor of the phalanges*—terminate in the digital region.

1. Anterior Extensor of the Metacarpus (Extensor Metacarpi Magnus) (Figs. 179, 11; 181, 15; 182, 9).

Synonyms.—Epicondylo-premetacarpeus—*Girard.* It represents the two external radia's of Man. (*Humero-metacarpeus—Leyh.*)

Situation—Direction—Form—Structure.—This muscle, situated in front of the radius, in an almost vertical direction, is composed of a muscular body and a tendon. The first has the form of an inverted cone, is intersected by some aponeurotic layers, and is composed of muscular fibres slightly arciform at their superior extremities. The tendon, at first rounded, then flattened, commences below the middle third of the radius, and succeeds the inferior extremity of the muscular portion.

Attachments.—This muscle has its fixed insertion: 1. By the upper extremity of its fleshy fibres, on the crest that limits, behind and below, the musculo-spiral groove of the humerus. 2. Above and in front of the inferior articular surface of the humerus, by means of a strong fibrous band common to it and the anterior extensor of the phalanges, and which expands on the deep face of these two muscles in becoming intimately united with the capsular ligament of the elbow articulation. Its movable insertion takes place on the anterior and superior tuberosity of the large metacarpal bone, by the inferior extremity of its tendon.

Relations.—The muscular portion is covered by the antibrachial aponeurosis and the short extensor of the forearm. It covers the anterior face of the radius, as well as the elbow articulation; outwards and behind, it is in contact with the inferior extremity of the short flexor of the forearm or humeralis obliquus, the aponeurosis of which adheres intimately to the arciform portion of the fibres of the anterior extensor of the metacarpus, and appears to attach this muscle to the deltoid imprint. Its tendon covers a small portion of the anterior aspect of the radius, and enters the internal vertical groove channeled in front of the inferior extremity of that bone; afterwards it passes over the capsular ligament of the carpus, and is maintained against that membranous expansion by a wide fibrous sheath, through which it glides by the aid of two synovial membranes (Fig. 183). This tendon is crossed above the knee by that of the oblique extensor, which passes to its surface.

Action.—The name of this muscle indicates its function; it extends the metacarpus on the forearm.

2. Oblique Extensor of the Metacarpus (Extensor Metacarpi Obliquus) (Figs. 179, 13; 181, 21; 182, 14).

Synonyms.—Cubito-premetacarpeus, or radio-premetacarpeus—*Girard.* It is the representative of the long abductor and short extensor of the thumb in Man. (*Extensor metacarpi obliquus vel parvus—Percivall. Radio-metacarpeus—Leyh.*)

Situation—Form—Structure—Direction.—A small muscle situated at the internal side of the radius, beneath the anterior extensor of the phalanges, penniform in shape, strongly aponeurotic, and terminated by a tendou which turns obliquely round the anterior aspect of the radius, in passing downwards and inwards to reach the oblique channel on the inferior extremity of that bone, and to pass thence to the inside of the knee.

Attachments.—It has its origiu on the external side of the radius; its terminal tendon is fixed into the head of the internal metacarpal bone, by its fibres becoming mixed with those of the internal ligament of the carpus.

Relations.—It is covered by the anterior extensor of the phalanges and the antibrachial aponeurosis. It successively covers the anterior face of the radius, the tendon of the anterior extensor of the metacarpus, the radial groove lodging its tendon, and in which it glides by means of a small synovial bursa, as well as the internal ligament of the carpus.

Action.—It extends the metacarpus, and may make it pivot from within forwards.

3. Anterior Extensor of the Phalanges (Extensor Pedis) (Figs. 179, 14; 181, 15; 182, 9).

Synonyms.—Epicondylo-prephalangeus—*Girard.* The extensor communis digitorum of Man. (*Humero-prephalangeus—Leyh.*)

Situation—Direction—Extent—Form—Structure.—This is a long vertical muscle, situated external to and behind the anterior extensor of the metacarpus, which it resembles in being composed of a fleshy and a tendinous portion. The muscular portion extends from the inferior extremity of the humerus to above the lower third of the radius; it is fusiform in shape, intersected by aponeurotic layers, and bifid at its superior extremity.[1] The tendinous portion forms two unequal cords, which succeed the two terminal branches of the muscular part, and lie close to each other. These two cords enter the most external of the three grooves in front of the inferior extremity of the radius, and reach the anterior face of the carpal capsular ligament, against which they are maintained by an annular ligamentous apparatus. After passing from beneath this ring, the smallest, which is the most external, joins the tendon of the lateral extensor (Fig. 179, 15). The principal branch (Fig. 179, 14′) continues its course on the anterior aspect of the middle metacarpal bone and articulation of the fetlock, until it arrives in front of the digit; here it terminates on the os pedis, after widening in a remarkable manner, and after receiving, laterally, at the middle of the first phalanx, a reinforcing band which appears to be given off from the inferior extremity of the suspensory ligament of the fetlock.

Attachments.—It has its fixed attachment by the superior extremity of its muscular body. 1. Below the crest that limits, posteriorly, the musculo-spiral groove of the humerus. 2. In front of the inferior extremity of the humerus. 3. To the anterior border of the external ligament of the elbow-joint. 4. To the external and superior tuberosity of the radius. 5. To the external border of that bone. Its principal tendon is inserted into the pyramidal process of the third phalanx, after being successively attached to the capsular ligament of the fetlock-joint and the anterior surfaces of the first two phalanges.

Relations.—The muscular portion, covered by the antibrachial aponeurosis, covers the articulation of the elbow, the anterior face of the radius, and the oblique extensor of the metacarpus; it responds, in front, to the anterior extensor of the same bone, to which it is intimately attached by its upper half; behind, to the lateral extensor of the phalanges. The tendinous cords cover the different parts already enumerated in describing the course of the muscle—that is, the anterior face of the radius, the carpal joints, the principal metacarpal bone, the articulation of the fetlock, and the first two phalanges. A vaginal synovial membrane envelops them at the knee, to facilitate their gliding in the radial groove and on the anterior aspect of the capsular ligament of the carpus; while the inner surface of the principal tendon is covered, in front of the fetlock, by a small vesicular capsule, and, still lower, by the synovial membranes of the two inter-phalangeal articulations.

Action.—This muscle extends the third phalanx on the second, that on the first, and this again on the metacarpal bone. It may also concur in the extension of the entire foot on the forearm.

(Two small muscles, which should be only considered as heads of this anterior extensor, have been particularly described by Thiernesse and Phillips, and named after these authors.

The *muscle of Phillips*, according to Leyh, is long and thin; it commences on the lateral external ligament of the ulnar articulation and the external superior tuberosity of the radius; it is directed obliquely downwards and forwards, lying beside the muscular portion of the common extensor. Towards the middle and outer aspect of the radius, it gives off a small tendon, which passes in the same sheath as the preceding, in front of the carpus, and continues

[1] This division, which has been noticed by several writers, has not been shown in Fig. 179. This is a mistake, as it is constantly present.

its course between the two tendons of the extensors of the phalanges to the near fetlock, where it becomes mixed with that of the lateral extensor, a little above the first phalanx.

The *muscle of Thiernesse* is smaller than that of Phillips, and situated at its inner side. It arises, in front of the transverse ligament of the ulna, by a muscular portion, becomes thinner as it descends, and terminates by a fine tendon which is confounded with that of the common extensor, towards the lower third of the forearm.)

4. Lateral Extensor of the Phalanges (Extensor Suffraginis) (Figs. 179, 16 ; 182, 13).

Synonyms.—Cubito or radialis-prephalangeus, according to Girard. The extensor minimi digiti of Man.

Direction—Situation—Extent—Form—Structure.—A small vertical muscle, situated at the external side of the forearm, between the preceding and the external flexor of the metacarpus, and formed of a fleshy body and a tendon. The body, not very considerable, and flattened, extends from the upper extremity of the radius to its lower fourth. The tendon (Fig. 179, 16′), at first rounded, then flattened, reaches the gliding groove which divides the external inferior tuberosity of the radius into two portions, passes to the external side of the carpus, crossing the lateral ligament common to the articulations of this region, and arrives at the anterior surface of the principal metacarpal bone, where it receives the small tendinous branch detached from the anterior extensor, as well as a strong fibrous band coming from the external side of the carpus (Fig. 179, 17). Afterwards, descending alongside the external border of the principal tendon of its congener, and united to it by a fibrous fascia, it gains the articulation of the fetlock, and expanding, terminates at the upper extremity of the first phalanx.

Attachments.—1. By its muscular body, to the external tuberosity of the radius, the external ligament of the elbow articulation, and to the bodies of the two bones of the forearm—*origin.* 2. By the inferior extremity of its tendon, to the capsule of the metacarpo-phalangeal articulation, and in front of the superior extremity of the first phalanx—*termination.*

Relations.—Its muscular portion, enveloped in a special aponeurotic sheath, responds: in front, to the anterior extensor of the phalanges; behind, to the external flexor of the metacarpus, and the perforatus and perforans muscles; outwards, to the antibrachial aponeurosis. The tendon, surrounded by a vaginal synovial sheath, in passing over the carpus, covers, beyond the knee, the anterior aspect of the metacarpus and the anterior ligament of the metacarpo-phalangeal articulation, over which it glides by means of a small vesicular synovial bursa. It is covered by a slight fascia, which separates it from the skin, and which is also spread over the tendon of the anterior extensor.

Action.—This muscle is an extensor of the digit, and also concurs in the extension of the entire foot on the forearm.

In the Ass, this muscle is proportionately much smaller than in the Horse.

B. Posterior Antibrachial Region.

This is composed of five flexor muscles grouped vertically behind the bones of the forearm. Three are situated superficially, and act on the whole of the foot; these are the *external flexor*, *oblique flexor*, and the *internal flexor of the metacarpus*. The other two, fixed to the digit by their inferior extremity, and covered by the preceding, are designated the *superficial* and *deep flexors of the phalanges*.

Superficial Layer.

1. External Flexor of the Metacarpus (Flexor Metacarpi Externus), or Posterior Ulnaris[1] (Fig. 179, 18).

Synonyms.—Epicondylo-supercarpeus—Girard. (*Humero-supercarpeus externus—Leyh.*)

Situation.—The external flexor of the metacarpus is situated at the external side of the forearm, between the lateral extensor of the phalanges and the oblique flexor.

Form—Structure—Attachments.—This muscle is elongated from above to below, flattened on both sides, thick in the middle, and intersected by very strong aponeurotic bands. It commences on the summit of the epitrochlea by a very powerful, but extremely short tendon. Inferiorly, it terminates by a second tendon longer than the preceding, and divides into two branches, an anterior and a posterior. The latter (Fig. 179, 20), short and wide, is inserted into the pisiform bone in becoming mixed with the oblique flexor. The former (Fig. 179, 19), rounded and funicular in shape, glides by means of a synovial bursa in the channel excavated on the external aspect of the pisiform bone, and which is converted into a canal by a little fibrous apparatus; this branch is afterwards fixed on the head of the external metacarpal bone, by being confounded with the external ligament of the carpus.

Relations.—Covered by the antibrachial aponeurosis, this muscle covers the two flexors of the digit. Its anterior border responds to the lateral extensor of the phalanges; the posterior to the oblique flexor. Its superior tendon lies behind the external ligament of the elbow-joint, and is covered deeply by the external *cul-de-sac* of the synovial capsule belonging to that articulation.

Action.—It flexes the foot on the forearm. (Leyh observes that it is more particularly concerned in what is known as "high action.")

2. Oblique Flexor of the Metacarpus (Flexor Metacarpi Medius), or Anterior Ulnaris (Fig. 180, 18).

Synonyms.—Epitrochlea supercarpeus—*Girard.* (*Humero-metacarpeus internus—Leyh.*)

Situation—Form—Structure.—This muscle, situated behind and within the forearm, is an exact counterpart of the preceding in form and structure.

Direction.—Bourgelat has improperly named it an oblique flexor, for its direction is vertical like that of the other muscles of this region.

Attachments.—It has its origin: 1. On the base of the epitrochlea by the tendinous fibres of its superior extremity. 2. On the olecranon, by a small, very thin, and very pale fleshy band, which is annexed to the principal muscular body, and soon unites with its posterior border. Its inferior tendon is undivided, and

[1] It is known that the bony eminences, hitherto termed in veterinary anatomy "epitrochlea" and "epicondyle," correspond: the first, to the epicondyle of Man, the second, to the epitrochlea. It need excite no surprise, therefore, to see the denominations given by Girard to the muscles of the posterior antibrachial region changed as above.

terminates on the pisiform bone, along with the external flexor, to which it is intimately attached.

Relations.—By its superficial face, with the antibrachial aponeurosis, which strongly adheres to its tendon ; by its deep face, with the flexors of the phalanges. Its anterior border is covered by the internal flexor ; the posterior responds to the external flexor.

Action.—It is a congener of the preceding.

3. Internal Flexor of the Metacarpus (Flexor Metacarpi Internus), or Palmaris Magnus (Fig. 181, 19).

Synonyms.—Epitrochlea metacarpeus—*Girard.* (*Humero-metacarpeus internus—Leyh.*)

Situation—Form—Structure—Attachments.—This muscle is situated within the forearm, against the posterior face of the radius, and in its general features resembles its congeners, the two preceding muscles. It is, however, not so wide, is thinner, and less aponeurotic. Its upper extremity is fixed, by tendinous fibres, to the base of the epitrochlea at the same point as the oblique flexor, with which it is confounded—*origin.* Its inferior extremity terminates in a long, thin, funicular tendon which passes through a fibrous sheath at the inner side of the knee, and is inserted into the head of the internal metacarpal bone—*movable insertion.*

Relations.—It is covered by the antibrachial aponeurosis, and covers the oblique flexor, the perforatus and perforans, as well as important blood-vessels and nerves. Its anterior border responds to the radius. A synovial sheath envelops its terminal tendon, and facilitates its movements in the fibrous canal through which it passes.

Action.—It is a congener of the preceding.

Deep Layer.

4. Superficial Flexor, Sublimis of the Phalanges, or Flexor Pedis Perforatus (Figs. 179, 181, 182).

Synonyms.—Epitrochlo-phalangeus—*Girard.* (*Humero-coronaris* or *humero-phalangeus—Leyh.*)

Situation.—The superficial flexor of the phalanges is situated, with its fellow, the perforans, beneath the flexors of the metacarpus, which form around them a kind of muscular envelope.

Form—Structure—Extent.—It is composed of a muscular and tendinous portion. The first, long, thin, prismatic, and divided by a great number of aponeurotic intersections, extends from the inferior extremity of the arm nearly to the carpus. The tendon, continuous with the inferior extremity of the muscular portion, receives at its origin an enormous fibrous production (*superior carpal* or *check ligament*), that arises from the eminence of insertion situated at the posterior face of the end of the radius, and which contracts somewhat intimate adhesions with the antibrachial aponeurosis, as well as with the perforans.

After being thus reinforced, this tendon passes through the carpal sheath and arrives behind the fetlock, where it forms a ring (Fig. 183, 21) for the passage of the tendon of the deep flexor. To this peculiarity is owing the designations of *perforatus* and *perforans*, given to the two flexors of the phalanges.

Afterwards, it is inflected forwards over the sesamoid groove, and terminates by two branches towards the middle of the digital region.

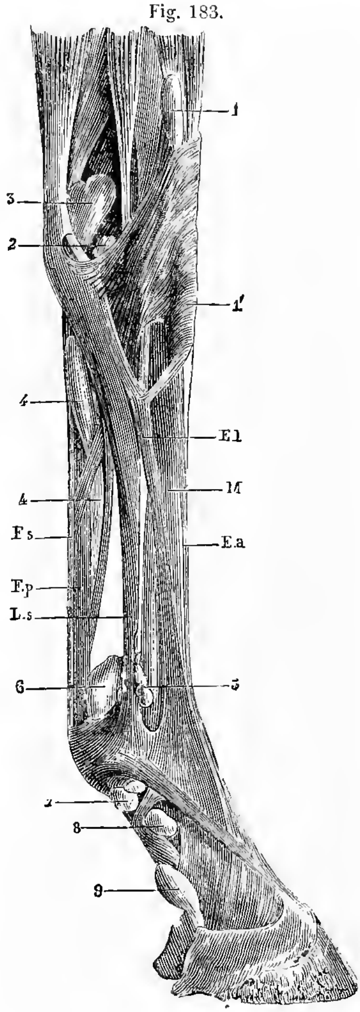
Attachments.—It takes its origin, in common with the perforans, at the summit of the epitrochlea, and is inserted, by the bifurcations of its tendon, into the extremities of the pulley formed behind the superior extremity of the second phalanx.

Relations. — The muscular portion, covered by the external and the oblique flexors of the metacarpus, may be said to be embedded in the perforans, to which it adheres in the most intimate manner. The tendon covers that of the latter muscle, and is in turn covered by the fibrous expansions of the two metacarpal and metacarpo-phalangeal sheaths, which are now to be described.

Carpal sheath is the name given to a very remarkable annular apparatus, formed by the superficial face of the common posterior ligament of the carpus, and by a thick expansion of white fibrous tissue, together constituting a perfect arch thrown across like a bridge, from the pisiform bone to the inner side of the carpus. This arch is continuous, above, with the antibrachial aponeurosis, and is prolonged, below, over the metacarpal portion of the flexor tendons. An extensive synovial membrane covers the internal aspect of the carpal sheath, envelops the perforatus and perforans in their passage through this canal, ascends above the carpus, and descends below the lower third of the metacarpal region (Fig. 183, 4, 4), where it is insinuated between the tendon of the perforans and its carpal ligament. This synovial membrane is strengthened in its middle portion by the walls of the carpal sheath; so that when hypersecretion takes place in it, this is only perceived by a swelling above the knee, externally, between the posterior face of the radius and the flexor muscles (Fig. 183, 3), and another swelling at the tendons behind the metacarpus.

The *Metacarpo-phalangeal sheath* is formed by the sesamoid groove, the posterior

Fig. 183.



TENDONS AND SYNOVIAL SHEATHS OF THE ANTERIOR LIMB OF THE HORSE.

M, Metcarpal bone; El, lateral extensor of the phalanges; Ea, anterior extensor of the phalanges; Fs, tendon of the superficial flexor of the phalanges (perforatus); Fp, tendon of the deep flexor of the phalanges (perforans); Ls, suspensory ligament of the fetlock. 1, Bursa for the tendon of the anterior extensor of the metacarpus; 2, supero-external *cul-de-sac* of the radio-carpal bursa; 3, superior *cul-de-sac* of the carpal bursa; 4, 4, inferior portion of same; 5, *cul-de-sac* of the capsule of the metacarpo-phalangeal articulation; 6, 7, 8, superior, middle, and inferior *culs-de-sac* of the sesamoid bursa; 9, inferior extremity of the same exposed by excision of the reinforcing sheath of the perforans tendon.

face of the principal navicular ligaments, that of the glenoid fibro-cartilage of the first interphalangeal articulation, and by the posterior pulley of the second phalanx (Fig. 183, 5). It is completed by a very wide membranous expansion applied against the flexor tendons, closely adherent to the perforatus on the median line of the digit, and fixed, laterally, to the phalangeal bones by the aid of three special fibrous bands (Fig. 184, 6, 7, 8). A very extensive vaginal synovial membrane covers the internal walls of this passage, and is reflected on the flexor tendons; it ascends along these tendons to the inferior extremities of the lateral metacarpals (Fig. 183, 6), and forms, inferiorly, a somewhat large *cul-de-sac* which envelops the perforans tendon (Fig. 183, 9), and behind the second phalanx lies against the posterior *cul-de-sac* of the articular synovial membrane of the foot, and also against the superior *cul-de-sac* of the navicular sheath (Fig. 137, 14). The metacarpo-phalangeal sheath is also named the *great sesamoid sheath;* but this designation is more frequently applied to the synovial membrane lining its walls. When this bursa is distended by the fluid it secretes, it projects at all those points where it is not supported by the fibrous walls of the metacarpo-phalangeal sheath. Then are formed above the metacarpo-phalangeal articulation, and between the suspensory ligament of the fetlock and flexor tendons, as well as below the fetlock—between the fibrous bands which attach the sheath to the first phalanx—those small tumours named "windgalls" (Fig. 183, 6, 7, 8). The inferior *cul-de-sac* (Fig. 183, 9) seldom appears externally, as it is sustained by the reinforcing sheath of the perforans tendon.

Action.—This muscle flexes the second phalanx on the first, that on the metacarpus, and the entire foot on the forearm. Its tendon, through the influence of the fibrous band which attaches it to the posterior face of the radius, acts mechanically as a stay while the animal is standing, by maintaining the metacarpo-phalangeal angle.

5. Deep Flexor of the Phalanges, or Flexor Pedis Perforans (Figs. 179, 181, 182, 183).

Synonyms.—Cubito-phalangeus, or radio-phalangeus—*Girard.* (*Humero-radio-phalangeus—Leyh.*)

Situation—Composition—Extent.—This muscle is situated immediately behind the radius, and is composed of three portions which unite at the carpus, to be continued to the inferior extremity of the digit by a long and powerful tendon.

Form, Structure, and Attachments of the muscular portion of the perforans.—The three muscular portions may be distinguished, in regard to their origin, into *humeral*, *ulnar*, and *radial*.

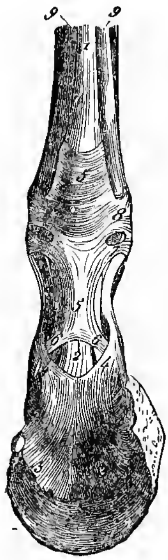
The *humeral portion* is the most considerable, and lies beside the perforatus; being three or four times the volume of that muscle, it is easily divided into several very tendinous fasciculi, which leave the summit of the epitrochlea along with the superficial flexor. The *ulnar portion*, situated between the external flexor and the oblique flexor of the metacarpus, is very short and conoid, thick at its superior extremity, contracted at its inferior, to which succeeds a long flat tendon, united below to the principal tendon; it has its origin on the summit and the posterior border of the olecranon. The *radial portion* (or *radialis accessorius*)[1] is the smallest, and is deeply concealed beneath the epitrochlean

[1] It represents the *flexor longus pollicis* of Man.

muscular portion. The fibres composing it are fixed to the posterior surface of the radius, where they are slightly divergent, and collect upon a small particular tendon, which is confounded with the common tendon after coutracting adhesions with the radial band of the perforatus.

Course and Attachments of the tendon.—The tendon which succeeds these three portions, enters the carpal sheath with that of the superficial flexor. Towards the middle of the metacarpal region, it receives a strong fibrous band from the great posterior ligament of the carpus (Figs. 179, 23; 182, 18), traverses the sesamoid annular apparatus of the perforatus tendon, passes between the two terminal branches of that tendon, over the pulley on the posterior face of the second phalanx, and afterwards widens to form a large expansion designated the *plantar aponeurosis*.

Fig. 184.



FLEXOR TENDONS OF THE PHALANGES IN THE HORSE.

1, Perforatus tendon; 2, tendon of the perforans at its exit from between the two branches of the perforatus; 3, 3, its insertion in the semilunar crest; 4, 4, the two lateral bands of its reinforcing sheath; 5, 5, fibrous expansion of the metacarpo-phalangeal sheath; 6, 7, 8, its lateral bands; 9, 9, suspensory ligament of the fetlock.

This aponeurosis glides, by its anterior face, over the inferior surface of the navicular bone, by means of a particular synovial membrane—the *navicular sheath*—and is covered, posteriorly, by a fibrous layer, noticed for the first time by H. Bouley, who considered it a *reinforcing sheath* for the perforans tendon. It is finally inserted into the semilunar crest of the os pedis, and the median imprints sitnated behind this crest, becoming confounded at its sides with the tissue of the lateral fibro-cartilages.

The *navicular sheath* is vesicular in form; it covers the navicular bone and the single ligament of the pedal articulation, becomes reflected on the plantar aponeurosis in front of this ligament, and ascends to the inferior *cul-de-sac* of the sesamoid sheath, where it is again reflected and continued by itself. It therefore forms two *culs-de-sac*—one superior, the other inferior—which are readily perceived in a longitudinal and vertical section of the digital region (Fig. 137, 15, 16). The first is in contact with the posterior *cul-de-sac* of the synovial membrane of the pedal articulation, and is separated from the inferior sac of the sesamoid sheath by a transverse layer of yellow fibrous tissue, which attaches the perforans tendon to the posterior face of the second phalanx. The second is situated beneath the interosseous ligament which unites the navicular bone to the third phalanx.

The *reinforcing sheath* of the perforans tendon is formed by a fibrous membrane, applied against the posterior face of the plantar aponeurosis. This membrane adheres intimately below, to the expansion it covers, and ends in becoming entirely confounded with it. It is fixed, at its borders, to the inferior extremity of the first phalanx, by means of two lateral bands (Fig. 184, 3, 4), and to the metacarpo-phalangeal sheath by a small median band. The latter passes on to the lower end of the great sesamoid synovial sheath, and divides it into two lobes, which are very visible when the sheath has been distended by injection.

Relations.—The epitrochlean muscular portion is covered, at its origin, by the external *cul-de-sac* of the elbow-joint, which sac also covers the other muscles attached to the epitrochlea—the external and oblique flexors of the metacarpus. It responds, anteriorly, with the radius and radial portion of the muscle; posteriorly, with the perforatus; externally, with the external flexor of the metacarpus; inwardly, with the internal and oblique flexors of the same ray.

The ulnar portion, covered by the antibrachial aponeurosis, covers the epitrochlean portion.

The radial division is comprised between the latter and the posterior face of the radius.

The tendon is in contact, posteriorly, with that of the perforatus; anteriorly, with the posterior ligament of the carpus, the suspensory ligament of the fetlock, and the sesamoid groove; by its sides, with the vessels and nerves of the digit. Its terminal expansion is covered by the plantar cushion, which adheres to it, in front, in the most intimate manner; it covers the navicular bone.

Actions.—This muscle flexes the phalanges on one another and on the metacarpus. It also concurs in the flexion of the entire foot on the forearm. The band which attaches its tendon behind the carpus, as well as its phalangeal reinforcing sheath, gives it the mechanical power necessary to support the angle of the metacarpo-phalangeal articulation and the digital region, while the animal is in a standing posture.

(In the "Deep Flexor," of Chauveau's description, we find included two portions which are separately named and described by Percivall and Gurlt. These are the *ulnaris accessorius* and *radialis accessorius* of the former, and the *cubito-ulnar* and *radial branches* of the latter. These, in reality, are portions of the perforans, and have been so designated in this treatise. Though arising independently, they terminate in the perforans tendon before it leaves the carpal sheath, and join with it in flexing the metacarpus and phalanges.)

Differential Characters in the Muscles of the Forearm in the other Animals.

A. **Ruminants.**—In the *Ox*, *Sheep*, and *Camel*, the *anterior extensor of the metacarpus* comports itself as in Solipeds.

The *oblique extensor* of the same region, terminates inside the upper extremity of the principal metacarpus.

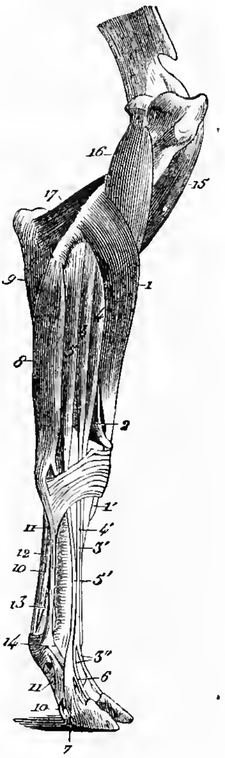
The *anterior extensor of the phalanges* offers a remarkable arrangement. It is divided throughout its length into two parallel portions: an external, which forms the *common extensor of the digits;* and an internal, the *proper extensor of the internal digit.*

a. The fleshy body of the *common extensor* (Fig. 185, 3) is a little more voluminous than that of the second muscle. Its tendon (3′) commences near the inferior third of the radius, passes over the knee, the metacarpal bone, and the metacarpo-phalangeal articulation. On arriving at the origin of the digits it bifurcates, and each of its branches goes to be inserted into the pyramidal process of the third phalanx (3″). This muscle, in extending the digits, brings them together, as Lecoq has judiciously remarked.

b. The *proper extensor of the internal digit* (Fig. 185, 4) much resembles the common extensor in volume, form, and direction. Its tendon (4′) passes, with that terminating the latter muscle, into one of the inferior grooves of the radius and over the capsular ligament of the carpus, where the two cords are enveloped by a common synovial sheath. Arrived at the metacarpo-phalangeal articulation, this tendon is placed at the eccentric side of the internal digit, and descends, gradually expanding, until it reaches the inferior extremity of this bone; towards the middle of the first phalanx, it receives from the suspensory ligament of the fetlock two constraining bands similar to those which, in Solipeds, bind the anterior extensor of the phalanges on the same bone. This tendon bifurcates inferiorly; one of its branches is attached to the anterior face of the second phalanx; the other, much wider than the first, covers the common external lateral ligament of the two inter-phalangeal articulations, and terminates on the whole external side of the third phalanx. In the *Sheep*, this second branch is slender, and is directed towards the heel, which it envelops by uniting its fibres with the perforans tendon and the plantar cushion.

The *lateral extensor of the phalanges* of Ruminants is thicker than in the Horse, and constitutes the *proper extensor of the external digit* (Fig. 185, 5). Its terminal tendon (4′, 6, 7) comports itself exactly the same as that of the proper extensor of the internal digit, and, consequently, does not merit special description. We may remark, with Lecoq, that these two muscles separate the digits from each other in extending them; they are, therefore, to a certain point, antagonists of the common extensor.

Fig. 185.



MUSCLES OF THE FOREARM OF THE OX (INTERNAL FACE).

1, Anterior extensor of the metacarpus; 1′, insertion of its tendon; 2, oblique extensor; 3, common extensor of the digits; 3′, its tendon; 3″, terminal bifurcation of that tendon; 4, proper extensor of the internal digit; 4′, its tendon; 5, proper extensor of the external digit; 5′, its tendon; 6, its branch of insertion into the second phalanx; 7, branch to the third phalanx; 8, external flexor of the metacarpus; 9, olecranian portion of the perforans; 10, tendon of the perforans; 11, tendon of the perforatus; 12, suspensory ligament of the fetlock; 13, the band it furnishes to the perforatus to form the ring through which the perforans passes; 14, the external band it gives off to the proper extensor of the external digit; 15, flexor brachii; 16, anterior brachial; 17, anconeus.

The oblique flexor of the metacarpus in the *Camel* has a very thin ulnar portion, rather aponeurotic than muscular. The inferior tendon of that muscle, at its insertion into the pisiform bone, detaches a band to the internal border of the carpus. In this animal, the *internal flexor* is attached to the superior extremity of the internal border of the metacarpus.

The *perforatus* of the *Ox* and *Sheep* is composed of two portions, the tendons of which unite towards the middle of the metacarpal region. The single tendon (Fig. 186, 1, 2, 3) which results from this union afterwards divides into two branches, each of which comports itself, in regard to the digits, as the single perforatus tendon does in the Horse, except that they receive from the suspensory ligament a fibrous band analogous to that which, in Solipeds, goes to the perforans tendon. This band (Fig. 185, 13) concurs in the formation of the annular ligament through which the latter tendon passes.

In the *Camel*, the muscular portion of the perforatus is not present, but is represented by a tendinous band, the arrangement of which is curious. It arises from the common posterior ligament of the carpus, and at its origin adheres firmly to the branch of the suspensory ligament of the fetlock which descends from the pisiform bone; it goes behind the perforans tendon, where it is completely covered by a very strong white membrane, and about the middle of the metacarpus it divides into two branches which separate at a very acute angle. Each of these branches glides in the sesamoidean sheath, the posterior wall of which is formed by a strong layer that is attached to the sides of the suspensory ligament and sesamoid bones. Below these bones, these two branches bifurcate in their turn; whence results four branches, which are inserted by pairs into the upper extremity of the two secondary phalanges, as in the other Ruminants.

In the *Ox*, the terminal tendon of the perforans does not receive any carpal band; this goes to the perforatus. Above the fetlock, it divides into two branches, one for each digit, which, after traversing the perforatus, terminates behind the inferior face of the third phalanx. There it is blended with the plantar cushion, the inferior interdigital ligament, and a fibrous fascia already noticed in the description of that ligament. This layer arises from the aponeurosis covering the flexor tendons in the metacarpal region; it descends on the heels, behind and outside the digits, remains united to that of the other digit by an intermediate fibrous fascia, and is attached to the enveloping sheaths of the flexor tendons, as well as to the superior interdigital ligament. Each terminates inferiorly, in becoming united to the proper extensor of the digit, the plantar cushion, the inferior digital ligament, and the deep flexor of the phalanges.

There is not, properly speaking, a phalangeal reinforcing sheath; though we may consider as such the superior fasciculi of the inferior interdigital ligament (Fig. 186, 6).

Of the three portions of the *perforans* in the *Camel*, the radial is the largest. The tendons of the three divisions become united in the carpal sheath, and the resulting tendon is easily divisible into two as far as the middle of the metacarpus; there it bifurcates, each branch passing into the terminal bifurcation of the band which represents the perforatus and goes to be inserted into the third phalanx, where it is covered by a small reinforcing sheath.

B. **Pig** (Fig. 187).—In this animal, the *anterior extensor tendon of the phalanges* passes to the superior extremity of the inner large metacarpal bone, and that of the *oblique extensor* to the small internal metacarpal.

Instead of the *anterior extensor of the phalanges*, four muscles are found—

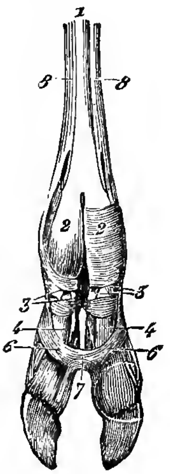
1. The proper extensor of the great internal digit alongside the anterior extensor of the metacarpus; its tendon terminates in an expansion on the outside of the great internal digit, after receiving, inwardly, a band from the corresponding interosseous muscle. It gives off, towards the middle of the metacarpus, a very thin branch which goes to the outside of the small internal digit.

2. The proper extensor of the great external digit, the largest of the four, terminates in the same manner as the preceding, on the outside of the great external digit.

3. The common extensor of the two internal digits, is continued by a tendon which bifurcates above the metacarpus, and gives off a branch that reaches the pyramidal process of the small phalanx of the internal digit, while the other branch—the most important—passes into the space between the metacarpals of the great digits, and bifurcates, in its turn, in front of the metacarpo-phalangeal articulation, to terminate on the pyramidal process of each of the great digits.

4. The common extensor of the two external digits, much smaller than the preceding, is in great part concealed beneath the proper extensor of the great external digit. Its somewhat thin tendon bifurcates in front of the metacarpus, to give a branch to the small external digit, going to the pyramidal process; and a second branch that goes to the principal tendon of the preceding muscle, from which it soon becomes detached to gain the small phalanx of the great external digit.

Fig. 186.



TENDINOUS AND LIGAMENTOUS APPARATUS OF THE POSTERIOR FACE OF THE DIGITAL REGION IN THE OX (POSTERIOR LIMB).

1, Perforatus tendon; 2, 2, its terminal branches; 3, 3, their bifurcation; 4, 4, perforans; 6, 6, superior bands of the inferior digital ligament attached to the first phalanx; 7, inferior interdigital ligament; 8, 8, suspensory ligament of the fetlock.

Lastly, there is in the Pig a representative of the proper extensor of the thumb and index, but its tendon—the thickness of a thread—is lost in that of the common extensor of the two internal digits.

There is also a round pronator along the anterior border of the internal ligament of the elbow-joint, as well as a *short supinator.* The latter, extremely thin, has no humeral insertion; it is thrown diagonally on the anterior and upper face of the radius.

With regard to the tendon of the *lateral extensor of the phalanges*, or *proper extensor of the external digit*, this spreads out on the outer face of that digit.

With regard to the muscles of the posterior antibrachial region, it is remarked that: 1. The anterior branch of the terminal tendon of the *external flexor* of the metacarpus passes to the head of the outer metacarpal bone. 2. The *internal flexor* terminates on the metacarpal of the great external digit. 3. The *perforatus* is formed by two muscular bodies, each terminated by a tendon inserted, inferiorly, into the second phalanx of one of the great digits. 4. The perforans is divided into four terminal branches, which arrive at the last phalanx of the great and small digits.

The *external flexor* of the metacarpus is almost transformed into a flat fibrous cord, extending from the epitrochlea to the pisiform bone, and to the outer side of the carpus, where it expands.

The *oblique flexor* of the metacarpus is reduced to a thin muscular cord without an ulnar insertion.

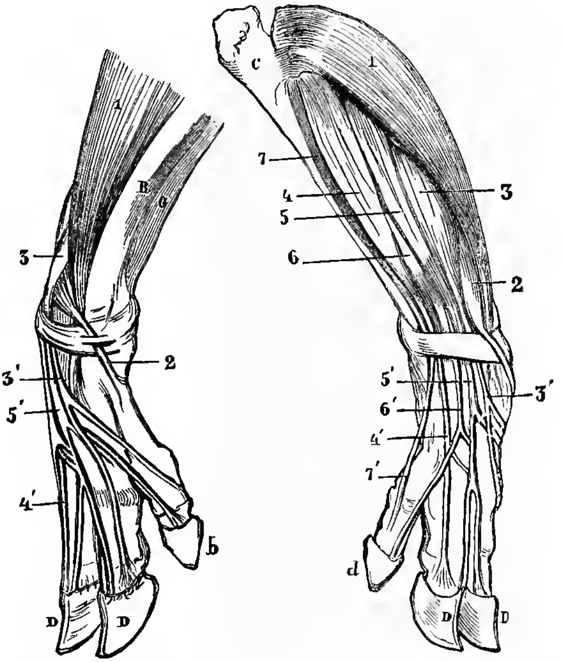
The *internal flexor* of the metacarpus, the most developed of the three, is inserted below on the metacarpal of the small internal digit.

The muscular portion of the *perforatus* throws off a fasciculus to the perforans, and bifurcates inferiorly; the superficial branch passes out of the carpal sheath, and terminates by a tendon, in the ordinary manner, on the second phalanx of the great external digit; the deep branch furnishes a fasciculus to the perforans, after which it enters the carpal sheath with the latter, and terminates on the great internal digit.

The *perforans* presents an epitrochlean portion, divided into two fasciculi, between which is interposed the perforatus—an ulnar portion very like that of the Horse, but inserted to the inner side of the olecranon; and an extremely rudimentary radial portion. These three portions unite into a common tendon which, on reaching the middle of the metacarpus, quadrifurcates to give a branch to each of the digits; the two branches for the small digits pass beneath a band which, from the sesamoid bones, is carried to the inner side of the second phalanx, and takes the place of the ring of the perforatus.

C. Carnivora.—In the *Dog* and *Cat*, the *anterior extensor* of the metacarpus divides, at

Fig. 187.



ANTERIOR ANTIBRACHIAL REGION OF THE PIG (EXTERNAL AND INTERNAL FACES).

1, Anterior extensor of the metacarpus; 2, oblique extensor of the metacarpus; 3, proper extensor of the great internal digit; 3′, its tendon, which gives off a thin branch to the small internal digit; 4, proper extensor of the great external digit; 4′, its tendon; 5, common extensor of the two internal digits; 5′, its tendon before bifurcation; 6, common extensor of the two external digits; 6′, its tendon before bifurcation; 7, proper extensor of the small external digit (lateral extensor of the phalanges); 7′, its tendon.

its lower extremity, into two branches, which exactly resemble those of the terminal tendons of the two external radial muscles of Man: one is inserted into the metacarpus of the index, the other into the metacarpus of the medius (Fig. 188, A, 5, 6, 7).

The *oblique extensor* passes to the metacarpus of the thumb; it furnishes, besides, a small particular branch that glides, by means of a sesamoid, over the third bone of the inferior row of the carpus, and is blended with the posterior ligament of the carpus (Fig. 188, A, 8; B, 4; D, 8); it separates the thumb from the other digits, but we think it scarcely adapted for the function of extensor.

The anterior extensor of the phalanges of Solipeds is replaced by a single muscle, the *common extensor of the digits*, terminated by a quadrifurcated tendon, whose branches are distributed to the four great digits (Fig. 188, A, 9, 9′).

The tendon of the *lateral extensor* is divided into three branches, which are inserted on the anterior face of the three outer digits, and are blended with the tendons of the common extensor, or with the fibrous bands furnished to these tendons by the interosseous metacarpal muscles.

The *external flexor of the metacarpus* comports itself as in the Pig. But the *oblique flexor* is covered by the perforatus, and its olecranian portion, thicker than in the other animals, is only united to the principal fleshy body altogether inferiorily. The *internal flexor* is slender and conoid; its tendon, thin and long, reaches the metacarpus of the index.

The *perforatus* of the *Dog* and *Cat* has a long, wide, and superficial body, separated from the perforans by the oblique flexor of the metacarpus. Its tendon passes outside the carpal sheath, and is divided into four branches, attached by their inferior extremity to the second phalanx of the four principal digits.

For the *perforans*, it is noted:

1. That the radial portion of the muscle (the *long flexor of the thumb* in Man) commences towards the superior extremity of the radius (Fig. 188, C, 4).

2. That the ulnar division is a semi-penniform muscle, attached by the superior extremities of its fibres to nearly the whole extent of the posterior face of the ulnar (Fig. 188, C, 3).

3. That the epitrochlean portion sends off, above the knee, a small particular fasciculus terminating in a very thin tendon, which becomes lost in the fibrous arch of the carpal sheath (Fig. 188, C, 6). This small muscle represents the palmaris brevis of Man.

The terminal tendon divides into five branches, one for each digit (Fig. 188, D, 4, etc.).

There have been already described in these animals:

1. Two *external radial muscles*, only distinct at their terminal extremity, and confounded for the remainder of their extent. This is the anterior extensor of the metacarpus in Solipeds (Fig. 188, A, 5, 6, 7).

2. A *long abductor of the thumb*, which appears to be the representative of the analogous muscle, and the short extensor of the same digit in Man. It is the oblique extensor of the metacarpus in the Horse (Fig. 188, A, 8).

3. A *common extensor of the digits;* the anterior extensor of the phalanges in the Horse (Fig. 188, A, 11).

4. A *proper extensor of the three external digits*, the proper extensor of the little finger in Man, or lateral extensor of the phalanges in the Horse (Fig. 188, A, 10).

5. A *posterior ulnar*, or external flexor of the metacarpus in the Horse (Fig. 188, A, 13).

6. An *anterior ulnar*, or oblique flexor of the metacarpus in the Horse (Fig. 188, D, 6).

7. A *great palmar*, corresponding to the internal flexor of the metacarpus in the Horse (Fig. 188, B, 8).

8. A *small palmar*, a dependency of the deep flexor of the phalanges (Fig. 188, C, 6).

9. A *flexor sublimis of the phalanges* (Fig. 188, D, 1).

10. A *deep flexor of the phalanges* (Fig. 188, C, 5; D, 3).

11. A *long flexor of the thumb*, united to the preceding muscle (the radial portion of the perforans (Fig. 188, C, 4).

But in *Carnivora* there are five additional muscles, which are not generally found in the other animals. These are: the *proper extensor of the thumb and index, long supinator, short supinator, round pronator*, and the *square pronator*. A special description will be given of these.

Muscles proper to the Forearm of Carnivora.

1. Proper Extensor of the Thumb and Index (Fig. 188, A, 11; B, 3).

Synonyms.—The *extensor secundi internodii pollicis* and *extensor indicis* of Man.

This is a very small muscle, composed of a fleshy body and a tendon. The first is thin and fusiform, and is situated under the lateral extensor; it has its origin with the oblique extensor of the metacarpus at the external side of the radius. The tendon crosses the anterior aspect of the knee, enveloped by the synovial sheath of the common extensor of the digits, under which it passes. It divides into two branches, one of which goes to the thumb, the other to the index.[1]

2. Long Supinator (Fig. 188, A, 12; C, 8).

This muscle only exists in the rudimentary state in *Carnivora*. Its existence in the Dog has even been denied, but this is an error; our researches have demonstrated that it is present, in a more or less evident manner, in all breeds.

It is a very delicate band, situated in front, and on the inner side of the anterior extensor

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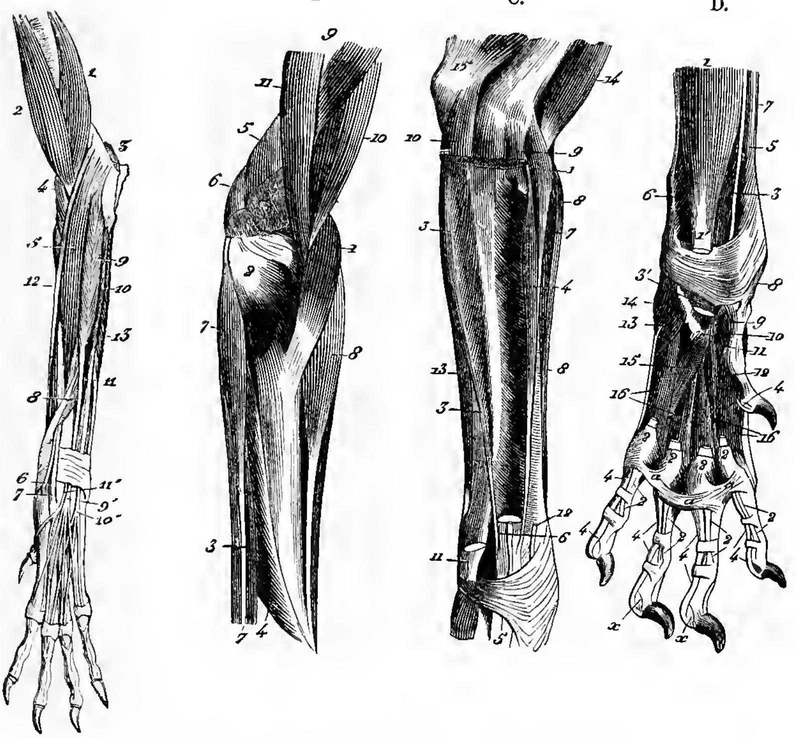
[1] In very powerful Horses, and more frequently in the Ox, we have met with traces of this muscle in the form of a deep fasciculus situated in front of the lateral extensor.

Fig. 188.



MUSCLES OF THE FOREARM AND PAW OF THE DOG.

A. *Anterior superficial region.*—1, Short flexor of the forearm (anterior brachial); 2, long flexor of the forearm (brachial biceps); 3, anconeus; 4, round pronator; 5, anterior extensor of the metacarpus (external radial); 6, its tendon of insertion, destined for the fourth metacarpal bone; 7, that which goes to the third; 8, external oblique of the metacarpus (long abductor and short extensor of the thumb); 9, common extensor of the digits; 9′, its terminal tendon at the point where it divides into four branches; 10, proper extensor of the three external digits, or lateral extensor of the phalanges in the horse; 10′, its terminal tendon at the commencement of its trifurcation; 11, proper extensor of the thumb and index; 11′, its terminal tendon; 12, 12, long supinator; 13, external flexor of the metacarpus (posterior ulnar).

B. *Deep anterior region.*—1, Round pronator; 2, short supinator; 3, proper extensor of the thumb and index; 4, oblique extensor of the metacarpus; 5, superior insertion of the anterior extensor of the metacarpus; 6, ditto of the anterior extensor of the phalanges; 7, proper extensor of the three external digits; 8, internal flexor of the metacarpus (great palmar); 9, levator humeri; 10, 11, long and short flexors of the forearm.

C. *Deep posterior region.*—1, Round pronator; 2, square pronator; 3, ulnar portion of the perforans; 4, radial portion of the same (long flexor of the thumb); 5, terminal tendon of the same; 6, tendon of the small palmar (division of the perforans); 7, anterior extensor of the metacarpus; 8, long supinator; 9, epicondyloid insertion of the perforatus, perforans, and oblique and internal flexors of the metacarpus; 10, olecranian insertion of the oblique flexor; 11, supercarpal insertion of the same; 12, terminal tendon of the internal flexor; 13, proper extensor of the external digits; 14, coraco-radialis; 15, tendon of the extensors of the forearm.

D. *Superficial posterior region, and the special muscles of the foot or hand.*—1, Perforatus; 1′, its tendon divided at its passage behind the carpal sheath; 2, ditto, its terminal branches; 3, perforans; 3′, its tendon divided after its exit from the carpal sheath; 4, ditto, its terminal branches; 5, tendon of the internal flexor of the metacarpus; 6, oblique flexor (anterior ulnar); 7, inferior extremity of the long supinator; 8, terminal tendon of the oblique extensor of the metacarpus; 9, short abductor of the thumb; 10, opponent of the thumb; 11, short flexor of the thumb; 12, adductor of the thumb, transformed, in the dog, into the adductor of the index; 13, short flexor of the small digit; 14, adductor of the small digit; 15, opponent of the small digit; 16, 16, metacarpal interosseous muscles. *a, a, a,* Bands which maintain the flexor tendons on the metacarpo-phalangean articulations, and limit the separation of the digits; collectively, they represent, in a rudimentary state, the palmar aponeurosis of Man.

of the metacarpus, taking its origin, along with that muscle, from the crest limiting the musculo-spiral groove of the humerus, behind the ridge; and terminating within the inferior extremity of the radius by fleshy and aponeurotic fibres. This small muscle can have but a very limited influence on the movements of the bones of the forearm, because of its trifling volume. As its name indicates, it acts in supination.

3. Short Supinator (Fig. 188, b, 2).

A triangular and slightly divergent muscle, covered by the anterior extensor of the metacarpus and the common extensor of the digits. It has its origin in the small fossa situated outside the humeral trochlea, by a flat tendon which is confounded with the external lateral ligament of the elbow-joint. It terminates above the anterior face and the inner side of the radius, by the inferior extremities of its fleshy fibres. Covered by the two preceding muscles, it covers the elbow articulation and the bone receiving its insertion. It ought to be considered, in Carnivora, as the principal supinator; it pivots the radius on the ulna, so as to turn the anterior face of the first bone outwards.

4. Round Pronator (Fig. 188, b, 1; c, 1).

Situated on the inner and upper part of the forearm, between the great palmar or internal flexor of the metacarpus and the interior extensor of the same ray, the round pronator is a thick and short muscle, which originates on the small, epicondyloid tuberosity of the humerus, and terminates at the internal side of the radius by aponeurotic fibres.

5. Square Pronator (Fig. 188, c, 2).

This muscle is situated immediately behind the bones of the forearm, beneath the muscular masses of the posterior antibrachial region. It extends from the insertion of the flexors of the forearm to near the carpus, and is formed of transverse fibres which pass directly from the ulna to the radius. It is, then, no longer, as in Man, a square muscle attached only to the lower fourth of these two bones. The two pronators are antagonists of the short supinator, turning forwards the anterior face of the radius and metacarpus.

Comparison of the Muscles of the Forearm of Man with those of Animals.

All the muscles of the forearm of *Man* are more or less perfectly represented in the forearm of Carnivora.

In Man, these muscles are described in placing the forearm in a state of supination, and are divided into three regions: anterior, external, and posterior.

1. Anterior Region.

This comprises eight muscles:

1. The *round pronator*, absent in animals except the Carnivora. This muscle forms the internal oblique prominence in the bend of the elbow. It leaves the epitrochlea and the coronoid process of the ulna, terminating on the middle third of the external face of the radius.

2. The *great palmaris*, which corresponds to the internal flexor of the metacarpus of the Horse. Situated within the preceding, it is attached, above, to the epitrochlea; below, to the base of the second metacarpal. It is more especially a flexor of the hand.

3. The *small palmaris*, the presence of which is not constant, and is represented in the Dog by a portion of the deep flexor of the phalanges.

4. The *superficial flexor* or *perforatus* has two planes of muscular fibres. The superficial plane is destined to the tendons of the medius and annularis; the deep plane to the tendons of the index and little finger. These tendons are fixed into the secondary phalanges of the above-named digits.

5. The *anterior ulnar* resembles the oblique flexor of the metacarpus of the Horse. It is inserted, above, into the epitrochlea and the olecranon; below, in the pisiform bone. Its action is transmitted, by a fibrous band, from this bone to the fifth metacarpal. It flexes the hand by inclining it inwards.

6. The *deep flexor* or *perforans* is resolved into two fasciculi: one, the internal, for the little finger, the annularis, and the medius; the other, the external, for the index. The three first tendons are at first united to each other by fibrous bands, and together pass through a sheath formed by the perforatus.

7. The *proper flexor of the thumb*, represented in the Dog by the radial portion of the perforans. It is attached, for one part, to the upper three-fourths of the anterior face of the radius, the interosseous aponeurosis, and the coronoid process of the ulna; on the other part, to the second phalanx of the thumb.

8. The *square pronator*, a thick, quadrilateral muscle with transverse fibres, situated at the deep and inferior portion of the forearm. This muscle in the Dog is much more extensive in length.

2. External Region.

The muscles of this region are four in number, two of which, the *supinators*, are only represented in Carnivorous animals:—

1. The *long supinator* forms a prominent mass at the bend of the elbow. It is attached to

Fig. 189.

SUPERFICIAL MUSCLES OF HUMAN FOREARM.

1, Biceps, with its tendon; 2, brachialis anticus; 3, triceps; 4, pronator radii teres; 5, flexor carpi radialis; 6, palmaris longus; 7, a fasciculus of flexor sublimis digitorum; 8, flexor carpi ulnaris; 9, palmar fascia; 10, palmaris brevis; 11, abductor pollicis; 12, flexor brevis pollicis; 13, supinator longus; 14, extensor ossis metacarpi, and extensor primi internodii pollicis.

Fig. 190.

DEEP LAYER OF SUPERFICIAL MUSCLES OF HUMAN FOREARM.

1, Internal lateral ligament of elbow-joint; 2, anterior ligament; 3, orbicular ligament of radius; 4, flexor profundus digitorum; 5, flexor longus pollicis; 6, pronator quadratus; 7, adductor pollicis; 8, dorsal interosseous of middle, and palmar interosseous of ring, finger; 9, dorsal interosseous muscle of ring-finger, and palmar interosseous of little finger.

the inferior third of the external border of the humerus, and to the base of the styloid process of the radius. It is a flexor of the forearm, not a supinator, as its name indicates.

2. The *first external radial* is represented by a portion of the anterior extensor of the metacarpus of animals. It commences at the inferior part of the external border of the humerus, and terminates at the posterior part of the base of the second metacarpal.

3. The *second external radial*, also represented by a portion of the anterior extensor of the metacarpus, terminates at the base of the third metacarpal.

4. The *short supinator*, a muscle bending round the upper third of the radius, is the essential agent in supination.

3. Posterior Region.

The muscles of this region, divisible into two layers, are:—

1. The *common extensor of the digits*—anterior extensor of the phalanges of the Horse—divided into four tendinous branches which pass to all the fingers, except the thumb.

2. The *proper extensor of the little finger*, whose tendon is joined to the branch of the common extensor that passes to the auricularis—the lateral extensor of animals.

3. The *posterior ulnar*, corresponding to the external flexor of the metacarpus of the Horse. It goes to the epicondyle at the upper extremity of the fifth metacarpal.

4. The *long abductor of the thumb*, resembling a portion of the oblique extensor of the metacarpus of animals. This muscle is attached to the posterior face of the ulna and radius, and the upper extremity of the first metacarpal.

5. The *short extensor of the thumb*, which is also represented in animals by a portion of the oblique extensor of the metacarpus.

6. The *long extensor of the thumb*, arising from the ulna, and inserted into the second phalanx of the thumb. This muscle limits, inwardly, the excavation termed the *anatomical snuff-box*.

7. The *proper extensor of the index*, whose tendon is confounded with the branch of the common extensor passing to this digit.

These two latter muscles, blended in the Dog, exist only in a rudimentary state in the other animals.

We will say nothing of the *anconeus*, placed in the antibrachial region by anthropotomists, and which has been described in the posterior brachial region.

Muscles of the Anterior Foot or Hand.

These will be studied successively in Carnivora, the Pig, Solipeds, and Ruminants.

A. Muscles of the Anterior Foot or Hand of Carnivora.

All the muscles of the human hand are found in that of Carnivora, some perfectly developed, others quite rudimentary. These muscles are: 1. The *short abductor of the thumb*. 2. The *opponent of the thumb*. 3. The *short flexor of the thumb*. 4. An *adductor of the index—adductor of the thumb in Man*. 5. The *cutaneous palmar*. 6. The *adductor of the small digit*. 7. The *short flexor of the small digit*. 8. The *opponent of the small digit*. 9. The three *lumbrici*. 10 Four *interosseous metacarpals*.

1. Short Abductor of the Thumb (Fig. 188, d, 9).

This is rudimentary, like the digit it is intended to move, and is situated behind the metacarpal bone of the thumb; it is composed of very pale fleshy fasciculi, which are continued inferiorly by some tendinous fibres. It has its origin at the carpal arch, and terminates on the metacarpal bone of the thumb, as well as at the external side of the superior extremity[1] of the first phalanx. It is a flexor and abductor of the thumb.

2. Opponent of the Thumb (Fig. 188, d, 10).

This vestige of the thick short muscle which bears the same name in Man is situated beneath and within the preceding, in a slightly oblique direction downwards and outwards. Pale and almost entirely muscular, it is attached to the posterior ligament of the carpus and the metacarpal bone of the thumb. Owing to the conformation of this digit in Carnivora, this muscle cannot act as it does in Man in producing the opposition of the thumb; it only draws it towards the axis of the hand, and is therefore merely an adductor of the thumb.

3. Short Flexor of the Thumb (Fig. 188, d, 11).

A very small muscle, deeper in colour than the other two, and situated between them, the adductor of the index, and the fourth interosseous muscle. It is fixed, by its superior extremity, in the mass of the posterior carpal ligament, and attached, below, to the internal side of the first phalanx. It is a somewhat extensive flexor of the thumb.

4. Adductor of the Index (Fig. 188, d, 12).

Synonym.—The adductor of the thumb in Man.

Elongated, prismatic, compressed on each side, included between the third and fourth

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[1] It is necessary to remember that the position of the digits is considered in relation to the axis of the hand—that is, the median line separating the medius from the annularis.

interosseous muscles, and concealed by the tendinous portion of the common flexor of the digits, this muscle is attached, superiorly, to the posterior carpal ligament with the third interosseous muscle. It is fixed, inferiorly, by means of a small flattened tendon, along the superior and internal side of the first phalanx of the index. It is regarded as the adductor of the thumb in Man transformed into an adductor of the index, in consequence of the atrophy of the fifth digit.

5. Cutaneous Palmar (Palmaris Brevis).

A thick, hemispherical, musculo-adipose body, forming the base of the exterior tubercle placed behind the carpus. It adheres intimately to the skin by its superficial face, and deeply to the aponeurosis covering the muscles of the hand.

6. Adductor of the Small Digit (Fig. 188, D, 14).

This muscle is superficially situated, external to, and behind the outer metacarpal bone, and is composed of a thick, conical fleshy body, concave on its anterior surface, convex posteriorly, and of a long, thin, and flat tendon, which succeeds the inferior extremity of the muscular portion.

It is attached, by the superior extremity of the latter, to the pisiform bone; the tendon terminates outside the superior extremity of the first phalanx of the small digit.

This muscle separates that digit from the axis of the hand, and is therefore an abductor and not an adductor, as its name would indicate. That name has been given to it in Man, because the hand has been considered in a state of supination, a position in which it is effectively an adductor in regard to the median plane of the body. If this name has been preserved here, it is owing to a desire not to import any new element of confusion into a nomenclature already too complicated.

7. Short Flexor of the Small Digit (Fig. 188, D, 13).

Situated within the preceding, in a slightly oblique direction downwards and outwards, flattened before and behind, triangular, and almost entirely muscular, this muscle derives its origin from a ligament which unites the pisiform bone to the metacarpal region, and terminates inferiorly on the tendon of the adductor, whose congener it is. It may also concur in the flexion of the small digit, though to a very limited degree.

8. Opponent of the Small Digit (Fig. 188, D, 15).

A muscle elongated from above downwards, flattened before and behind, situated under the perforans tendons, behind the second interosseous muscle, in a direction slightly downwards and outwards. It originates from the posterior ligament of the carpus, and terminates within the superior extremity of the first phalanx of the external digit by a small tendon. It acts as an adductor by drawing the small digit towards the axis of the hand.

9. Lumbrici.

These small muscles, which owe their name to the resemblance they bear to the lumbricales or earthworms, are only three in number in Carnivora. They occupy the interval between the four chief branches of the perforans tendon, from which they have their origin; they terminate, by a small fibrous digitation, on the extensor tendons of the three external digits. It is often impossible to trace them so far; for they are frequently observed to stop within and above the first phalanx of the digits for which they are destined. Their functions cannot be rigorously defined in Carnivora.

10. Metacarpa Interosseous Muscles (Fig. 188, D, 16, 16).

These are four thick and prismatic muscular fasciculi, elongated from above to below, bifid at their inferior extremity, placed parallel to one another, in front of the flexor tendons, from which they are separated by a thin aponeurotic layer, and behind the four large metacarpals.

They have their origin on the posterior and lateral faces of these bones, as well as on the posterior carpal and intermetacarpal ligaments. Each terminates, by the two branches of its inferior extremity, on the great sesamoids of the digit to which it corresponds. There they are continued by a small tendon, which joins the chief extensor of the digit. These muscles oppose undue extension of the digits while the animal is standing, flex them on the metacarpal bones, and maintain the extensor tendons on the anterior aspect of the phalanges.

B. Muscles of the Anterior Foot in the Pig.

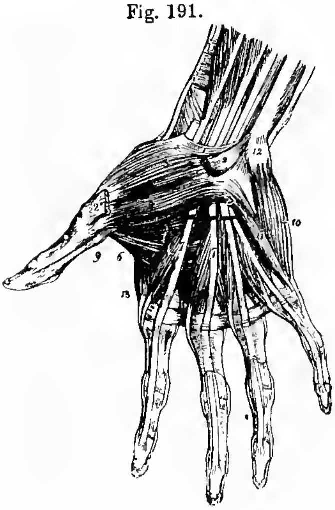
In our notes on the myology of this animal, we find:

1. A muscle which originates in the substance of the metacarpo-supercarpal ligament, and terminates on the proper extensor of the small external digit by a fibrous strip joined to the external fasciculus of the first interosseous muscle; it is also attached to the external sesamoid. This is, no doubt, the representative of the *short flexor of the small digit* in Man and the Carnivora.

2. A single, but very voluminous *lumbricus*, fixed, at the one part, to the perforans tendon, and at the other, to the proper extensor tendon of the small internal digit (index), as in the preceding muscle.

3. Four *interosseous metacarpal muscles*, similar to those in the Dog, and whose terminal digitations join the proper extensor tendons. The interosseous muscles of the two small digits are not only divided at their inferior extremity, but throughout their whole length are observed to be two very distinct fasciculi, one superficial and external, the other deep and internal. The fibrous membrane covering these muscles, and which separates them from the perforans tendons, is much thicker than in the Carnivora.

Fig. 191.



MUSCLES OF HUMAN HAND.

1, Annular ligament; 2, 2, origin and insertion of the abductor pollicis muscle; 3, flexor ossis metacarpi, or opponens pollicis; 5, deep portion of flexor brevis pollicis; 6, adductor pollicis; 7, 7, lumbricales muscles arising from the deep flexor tendons, upon which the figures are placed; 8, a tendon of deep flexor; 9, tendon of flexor longus pollicis; 10, abductor minimi digitii; 11, flexor brevis minimi digitii; 12, pisiform bone; 13, first dorsal interosseous muscle, the abductor indicis.

C. Muscles of the Anterior Foot in Solipeds.

In Solipeds, only two *lumbrici* and two *interosseous metacarpal* muscles have to be described.

1. The *lumbrici* originate at the right and the left of the perforans tendon, above the sesamoid annular band of the perforatus. They each terminate by a thin tendon, which is lost in the fibrous layer enveloping the elastic cushion of the ergot of the fetlock.

2. The *interosseous* muscles (*anterior lumbrici—Percivall*) have been wrongly considered by French veterinary anatomists as lumbrici muscles, and are described by them as the *superior*, or *great lumbrici*. Situated within the rudimentary metacarpal bones, these two little muscles are formed of a very delicate fleshy mass embedded in the fibrous tissue surrounding the head of the metacarpal bones, and of a long tendon which descends to the metacarpo-phalangeal articulation, to be confounded with the band furnished to the anterior extensor of the phalanges by the suspensory ligament. Sometimes this tendon is directly united to one of the extensors of the phalanges.

These two muscles represent the interossei of the lateral digits. With regard to those of the median digit, they are transformed, as we have already seen, into a fibrous brace which constitutes the suspensory ligament of the fetlock.

D. Muscles of the Anterior Foot in Ruminants.

These animals have no muscles, properly speaking, in the region of the foot; in fact, we only find in them the suspensory ligament of the fetlock, which is the interosseous of the two complete digits.

Comparison of the Hand of Man with that of Animals.

The muscles of Man's hand are numerous and well-developed, in consequence of the extent and variety of the movements of its various parts. They are divided into three groups: the external, or group of the *thenar eminence*, induce the movements of the thumb; the internal, or group of the *hypothenar eminence*, those of the little finger; and the middle group, occupying the metacarpal spaces, comprising the *interosseous muscles*. In addition, there is found in the hand a cuticularis muscle, the cutaneous palmaris (*palmaris brevis*).

The *cutaneous palmaris* occupies two-thirds of the hypothenar eminence; its fibres are directed downwards and inwards. It corrugates the skin on the ulnar border of the hand.

A. Muscles of the Thenar Eminence.

These muscles, nearly all present in the Dog, are:

1. The *short adductor of the thumb*, whose fibres, leaving the lower portion of the antibrachial aponeurosis, the process of the trapezius and the scaphoides, are succeeded by a tendon which is inserted into the upper extremity of the first phalanx of the thumb.

2. The *opponent (opponens) of the thumb*, which passes from the anterior part of the trapezium to the external border, and near the anterior face of the first metacarpal.

3. The *short flexor of the thumb*, a muscle adjoining the preceding, and which is resolved into two series of fibres—a deep and a superficial.

4. The *short adductor of the thumb*, a triangular muscle, occupying the outer half of the hollow of the palm. It is attached to the os magnum, along the entire length of the third metacarpal bone and, by a tendon, to the sesamoid and supero-internal tuberosity of the first phalanx of the thumb.

B. Muscles of the Hypothenar Eminence.

These muscles are: 1. The *abductor of the little finger*, a small fusiform muscular body, which is attached, above, to the pisiform bone, and below to the supero-internal part of the first phalanx.

2. The *short flexor of the little finger*, situated without the preceding, fixed in one part to the process of the unciform bone, and in the other to the inner part of the first phalanx.

3. The *opponent (opponens) of the little finger*, a triangular muscle, situated below the preceding. It is inserted into the process of the unciform bone, then into the inner border of the fifth metacarpal and the adjacent portion of its anterior face.

C. Interosseous Muscles.

"The interosseous muscles are situated in each interosseous space, two for each space, and are divided into *dorsal* and *palmar*. As there are four interosseous spaces, there ought to be eight muscles; but it is usual to exclude the short adductor of the thumb, because of its special insertions; this reduces the total number of interosseous muscles to seven—four dorsal and three palmar.

"These small muscles arise from the lateral faces of the metacarpals to the lateral and upper portions of the first phalanges. By their contraction, they incline these phalanges laterally, and consequently carry the corresponding digit inwards and outwards."

It may be added that the *lumbrici* muscles are small muscular and tendinous fasciculi, annexed to the tendons of the deep flexor of the phalanges; their tendons terminate on the external side of the four last digits, in becoming blended with the interossei.

Article III.—Muscles of the Posterior Limbs.

These form four principal groups: the muscles of the croup, thigh, leg, and foot.

Muscles of the Gluteal Region, or Croup.

This region is composed of three superposed muscles, which are applied to the ilium, and are distinguished according to their relative situation as the *superficial*, *middle*, and *deep gluteus*.[1]

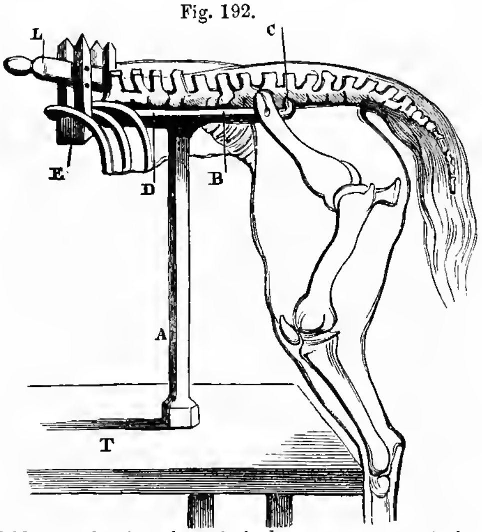
They are covered by a thick fibrous fascia—a prolongation of the aponeurosis of the great dorsal—which is continued backwards over the muscles of the posterior crural region, where it is confounded with the superficial layer of the fascia lata. This *gluteal aponeurosis* is fixed to the external angle of the ilium and the supersacral spine. By its deep face it gives attachment to several fasciculi of the superficial and middle glutei.

[1] For the justification of the employment of these new denominations, see note, p. 230.

Preparation.—1. Place the animal on its side, or, better, in the second position. 2. Remove the skin from this region in order to show the gluteal aponeurosis, and to study its extent, attachments, and relations. 3. Cut away this aponeurosis to expose the anterior point of the middle gluteus and the muscular portion of the superficial. To prepare the aponeurotic portion of the latter muscle, the sacro-sciatic insertion of the long vastus must be detached by the scalpel and thrown downwards. 4. Incise the superficial gluteus near its femoral insertion, and reverse it on the sacral spine, so as to lay bare the external face of the middle or principal gluteus. 5. Divide this muscle near its femoral insertions, taking care not to injure these, and remove the whole of its mass, studying meanwhile the nature of its relations to the parts it covers; the deep or small gluteus then becomes apparent, and may be conveniently examined.

To render the dissection and study of these muscles easier, the hind quarters may be arranged as in Fig. 192. A special upright support passes between the last ribs, and a horizontal lever maintains the lumbar region fixed in a kind of metallic fork. By this arrangement the croup and hips are kept in a good direction, the mass being made tense, so that they can be dissected nearly in their normal relations.

Fig. 192.



T, Table; A, showing the principal support; B, posterior horizontal bar; C, blunt point at the end of the branches of the T placed at the extremity of the posterior branch; D, anterior horizontal branch terminated by vertical branches, E, on which the last pair of ribs rest; L, notched lever which keeps the animals hind quarters on the support *ad hoc.*

1. Superficial Gluteus (Gluteus Externus) (Fig. 193, 2, 4).

Synonyms. — Ilio-trochanterius medius—*Girard.* Gluteus minor —*Bourgelat.* Gluteus medius—*Rigot* and *Lafosse.* The gluteus magnus of Man. (*Ilio-trochanterius externus—Leyh.*)

Composition— Situation.— This muscle is composed of two portions—one anterior, the other posterior, closely joined, and situated beneath the gluteal fascia. They form the most superficial portion of the fleshy masses of the croup and inner face of the thigh.

Form—Structure— Attachments.—A. The *anterior portion* (the *superficial* or *middle gluteal* muscle of veterinary anatomists) comprises a muscular and an aponeurotic division. The first is triangular in shape, deeply notched in its upper border, so that it is sometimes divided into two parts—an external and an internal. Its fasciculi are very thick and loosely united; they all pass backwards and downwards, to converge in a flattened tendon which terminates the inferior angle of the muscle. The aponeurosis, also triangular, is confounded in front with the posterior border of the muscular portion and its terminal tendon, and is insinuated behind, beneath the posterior portion; it degenerates into connective tissue at its inner and upper border. The anterior part of the muscle has its *fixed insertion:* 1. On the internal aspect of the gluteal aponeurosis, by the superior extremity of its muscular fasciculi. 2. On the postero-external angle of the ischium, and the sciatic ligament, by the internal border of its aponeurotic portion. It has its movable insertion, by means of its terminal tendon, on the small external or third trochanter of the femur.

B. The posterior portion[1] (anterior portion of the *long vastus* of veterinary anatomists), the largest of the two, is applied to the aponeuroses of the preceding, and extends from the sacral spine to the inferior extremity of the thigh. It is prismatic, very broad at its upper end, and singularly contracted at the opposite extremity. A wide and strong fibrous band, which becomes aponeurotic towards the superior extremity of the muscle, covers the inner face in its inferior portion. The muscular fibres appear to become longer as they are more posterior; all pass from the upper end to collect on the tendinous layer.

The muscle arises, by the superior extremity of its fasciculi, on the gluteal fascia, sacral spine, sacro-sciatic ligament, the enveloping aponeurosis of the coccygeal fascia, and the ischiatic tuberosity. It terminates: 1. On the circular imprint situated behind the trochanter minor, by a branch detached from the

Fig. 193.

SUPERFICIAL MUSCLES OF THE CROUP AND THIGH OF THE HORSE.

1, Middle gluteus; 2, anterior portion of the superficial gluteus; 3, tensor fascia latæ; 4, posterior portion of the superficial gluteal; 5, biceps femoris; 5′, semitendinosus; 6, semimembranosus.

deep tendon. 2. On the anterior face of the patella, along with the external patellar ligament, by the inferior extremity of that tendon.

Relations.—Externally, with the gluteal fascia, which, in being prolonged on the posterior portion, increases in thickness, and becomes more or less elastic. Inwardly, with the middle gluteus (*gluteus maximus*), the trochanter major, and deep layer of the *fascia lata*, which isolates it from the vastus externus; with the anterior face of the patella, on which it glides by means of a synovial bursa before being inserted; with the sciatic nerves and great adductor of the thigh. By its anterior border it is closely united to the muscle of the *fascia lata*; by

[1] Lesl re proposes to name it the *accessory of the superficial gluteus.*

its posterior border it has relation, inferiorly, with the biceps femoris, and higher, with the semitendinosus, which slightly covers it.

Action.—This muscle has been justly considered by Lafosse as an abductor of the thigh. Bourgelat wrongly regarded it as an extensor, and Girard and Rigot have repeated his error. Lecoq has proved that it rather produces flexion than extension. The posterior portion is an abductor of the entire limb and an extensor of the thigh, when the sacrum is its fixed point; it plays a part in *rearing*, when the fixed point is the leg.

2. Middle Gluteus (Gluteus Medius, Gluteus Maximus) (Figs. 193, 1; 194, 1).

Synonyms.—Ilio-trochanterius magnus—*Girard.* Gluteus maximus—*Bourgelat, Lafosse, Rigot,* etc. Gluteus medius of Man. (*Superior portion of the great ilio-trochanterius—Leyh.*)

Volume—Situation.—This muscle, the largest of the glutei, is of considerable volume, and is applied against the iliac fossa, the sacro-sciatic ligament, and the longissimus dorsi.

Form and Structure.—It is elongated from before to behind, wide and very thick in its middle, prolonged forward by a thin point, and terminated behind by three branches of insertion—two tendinous and one muscular. The muscular fasciculi entering into its composition are generally very thick, and more or less long; all converge towards the posterior insertions of the muscle.

Attachments.—1. By the superior or anterior extremities of the muscular fasciculi, to the internal aspect of the gluteal fascia, the aponeurosis of the longissimus dorsi, the superior face and the two anterior angles of the ilium, the two ilio-sacral ligaments, and a small portion of the sacro-sciatic ligament. 2. On the trochanter major by its three posterior branches: the first, or median, is a thick, round tendon fixed on the summit; the anterior is formed by a second wide, thin, and flat tendon, which is inserted into the crest, after gliding over the convexity; the posterior is a small, triangular, fleshy slip, aponeurotic at its anterior border, by means of which it is attached behind the trochanter. This slip corresponds to the *pyramidalis* muscle of Man.

Relations.—Covered by the gluteal fascia and the superficial gluteal muscle, it covers the longissimus dorsi, which receives its anterior point, the iliac fossa, the deep gluteal, the ilio-sacral and sacro-sciatic ligaments, the sciatic nerves, and the gluteal nerves and vessels. Near the external angle of the ilium it is bordered by the fascia lata and the iliacus, which are closely united to it.

Action.—When its fixed point is superior, this muscle extends and abducts the thigh; but when the femur is fixed, it causes the pelvis to rock on the superior extremity of that bone, and assists in the act of *rearing.* In the first instance it acts as a lever of the first order; in the second, as one of the third order.

3. Deep Gluteus (Gluteus Internus) (Fig. 167, 5).

Synonyms.—Ilio-trochanterius parvus—*Girard.* Gluteus medius—*Bourgelat.* Gluteus minimus—*Lafosse* and *Rigot.* The gluteus minimus of anthropotomists.

Form—Situation.—A small, short, thick, and quadrilateral muscle, flattened above and below, situated beneath the preceding, and above the coxo-femoral articulation.

Structure and Attachments.—It is composed of voluminous muscular and tendinous fasciculi, which arise from the neck of the ilium and the supra-cotyloid ridge, to be directed outwards and backwards, and terminate within the convexity of the trochanter major.

Relations.—Its upper face responds to the middle gluteus; the inferior covers the coxo-femoral articulation, and strongly adheres to the fibrous capsule of that joint. This face is also separated from the rectus parvus and the origin of the rectus femoris by a very strong fibrous layer, which extends from the external border of the ilium to the base of the trochanter major. Its posterior border is in relation with the anterior gemellus of the pelvis.

Fig. 194.

SUPERFICIAL MUSCLES OF THE CROUP AND THIGH.

1, Middle gluteus, or gluteus maximus; 2, anterior spinous process of ilium; 3, muscle of the fascia lata, or tensor fascia latæ; 4, superficial gluteus, or gluteus externus; *, great trochanter of femur; 5, fascia lata; 6, patella, with insertion of rectus, 7, biceps femoris, or adductor magnus; 8, superior and, 9, lateral coccygeal muscles; 10, semitendinosus and semimembranosus; 11, 12, triceps abductor femoris; 13, fascia of the thigh; 14, vastus externus.

Action.—It is the special abductor of the thigh, and is also an accessory rotator of the femur inwards.[1] (Leyh says it is a congener of the preceding

[1] Lesbre is of opinion that the middle gluteus, such as it has been described here, comprises two superposed muscles which are distinct at their trochanterian insertion: the superficial is the middle gluteus of Man, and the deep the small gluteus of anthropotomists. Therefore the muscle we have described as the deep gluteal in the Horse has no representative in Man. Lesbre proposes to name it the *abducens trochanterius*. It should be the homotype of the inferior branch of the infra-spinatus, which is also absent in man, and which it would be reasonable to describe, by analogy, as the *abducens trochiterius*.

muscle, and therefore an extensor of the thigh. It may also maintain the capsular ligament tense.)

DIFFERENTIAL CHARACTERS IN THE MUSCLES OF THE GLUTEAL REGION IN THE OTHER ANIMALS.

A. **Ruminants.**—In the *Ox*, *Sheep*, and *Goat*, the two portions of the *superficial gluteus* are less distinct than in Solipeds (see Fig. 197). They form one muscle, remarkably developed, the inner face of which has no point of attachment on the femur; it glides behind the trochanter by means of a vast bursa, which is often the seat of pathological alterations—synovial tumours which constitute the *swellings* or *gout* of the larger Ruminants. Another synovial bursa, liable to the same maladies, covers the patellar tendon of the muscle on its passage over the external condyle of the femur, and facilitates its gliding on that bony eminence. Before joining the external patellar ligament, this tendon shows a very thick, fibro-cartilaginous enlargement, and receives some of the fibres of the external vastus.

Another arrangement in this muscle, which it is essential to recognize in a surgical point of view, is the union of the anterior border of the *superficial gluteus* of the Ox with the *fascia lata*, the two layers of which comprise that muscle between them, and closely adhere to each of its faces. It very frequently happens that, in emaciated cattle, this fascia is ruptured at the trochanter, and the latter, instead of gliding on the inner face of the superficial gluteus, slips before its anterior border to pass through the solution of continuity, where it is fixed so firmly that it is sometimes necessary to cut across the fibres of the muscle in order to give the limb liberty of movement.

The *middle gluteus*, not so thick as in the Horse, is not prolonged so far forward on the longissimus dorsi; and, on the contrary, the *deep gluteus*, more developed than in Solipeds, is readily divisible into two portions, of which Rigot has made two distinct gluteals. In the *Camel*, the *middle gluteus* does not go beyond the border of the ilium in front. The posterior portion of the *superficial gluteus* has an attachment to the external border of the femur.

B. **Pig.**—The gluteal muscles of this animal resemble those of the Sheep, though the posterior portion of the *superficial gluteus* does not always have a bursa for its passage over the external condyle of the femur.

C. **Carnivora.**—The *superficial gluteus*, in its general arrangement, resembles that of Man; its posterior portion, which is scarcely distinct, arises from the sacrum, and terminates, by an apoueurosis, below and behind the trochanter major. This aponeurosis receives, in front, a small fleshy band, which arises by tendinous fibres from the surface of the middle gluteus, next the external angle of the ilium. In these animals, also, the *middle gluteus* does not go beyond the lumbar border of the ilium, and terminates behind by a single branch.

COMPARISON OF THE GLUTEAL MUSCLES OF MAN WITH THOSE OF ANIMALS.

The gluteal muscles are distinguished, in regard to their volume, into great, medium, and small (see note, p. 230).

The *medium gluteus* does not extend beyond the crest of the ilium in front.

With regard to the *gluteus maximus*, it is inserted inwardly into the sacrum and the coccyx; below, into the external bifurcation of the linea aspera, from the trochanter major to the middle third of the femur, as in Solipeds.

The *gluteus parvus* is proportionately more extensive than in the Horse.

Muscles of the Thigh.

These have been divided into three secondary regions, which are: the *anterior femoral* or *patellar*, the *posterior femoral*, and the *internal femoral region.*

A. ANTERIOR FEMORAL REGION.

This region comprises three muscles situated in front of the femur: the *muscle of the fascia lata*, the *crural triceps*, and the *gracilis*.

Preparation.—1. Place the subject in the first position. 2. Study the fascia lata muscle immediately after removing the skin from this region. 3. Take away this muscle and the superficial gluteus, the semitendinosis and semimembranosis, the two adductors of the leg, the pectineus, and the two adductors of the thigh, to expose the three portions of the triceps. Separate these three muscular divisions from one another, commencing above where they are scarcely adherent. Dissect the gracilis at the same time.

1. Muscle of the Fascia Lata (Tensor Fascia Latæ, Tensor Vaginæ Femoris (Fig. 193, 3).

Synonyms.—Ilio-aponeuroticus—*Girard.* (*Tensor vaginæ—Percivall. Ischio-rotuleus externus—Leyh*).

Form—Situation.—A flat and triangular muscle, situated in front of the superficial gluteus, and outside the external vastus.

Structure—Attachments.—It comprises: 1. A flabelliform muscular portion, covered on its faces by tendinous fibres, and attached, superiorly, to the external angle of the ilium. 2. An aponeurosis named the *fascia lata*, continuous with the inferior border of the muscular portion, and soon divided into two superposed layers—one superficial, the other deep. The latter is insinuated between the posterior portion of the superficial gluteus and the external vastus, joins the terminal tendon of the anterior portion of that muscle, and is inserted into the external border of the femur. The first, which also appears to divide into two layers, is spread outwardly over the superficial gluteus, where it is confounded with the gluteal aponeurosis; and inwardly, over the internal crural muscles, to become united to the femoral aponeurosis. Below, it is prolonged to the patella, into which it is fixed; it is even continued below that bone, to join the terminal aponeurosis of the posterior branch of the long superficial gluteus.

Relations.—Outwards, with the skin; inwards, with the external vastus, the anterior rectus, and the iliacus; behind, with the superficial and middle glutei. In front, to a cluster of lymphatic glands, where it receives, on its aponeurosis, the insertion of the panniculus carnosus.

Action.—It flexes the femur by raising the entire limb, and renders tense its own terminal aponeurosis.

(In speaking of the uses of this muscle, Leyh states that—in addition to its being a flexor of the thigh and an extensor of the leg through its action on its aponeurosis—it maintains the position of the limb while the animal is standing, and allows the other muscles to become relaxed.)

2. Crural Triceps.[1]

An enormous muscle lying against the anterior and lateral aspects of the femur, composed of three portions which are not very distinct from each other for the greater part of their extent, and which are separately described as the *anterior rectus* or *straight muscle*, and the *vastus externus* and *internus*.

A. Anterior Straight Muscle of the Thigh (Rectus Femoris), Middle Portion of the Triceps (Figs. 194, 6; 197, 16).

Synonyms.—The ilio-rotuleus of *Girard.* (*Rectus—Percivall. Anterior ilio-rotuleus—Leyh.*)

This muscle is embedded between the two lateral portions of the triceps, and extends from the cotyloid angle of the ilium to the patella, in a direction slightly oblique forwards and downwards.

Form—Structure.—Elongated, thick, and fusiform, the rectus femoris offers, at its superior extremity, two short and flattened tendinous branches; its middle portion is formed of pale-red muscular fibres lying close to each other, and

[1] Following the example of M. Cruveilhier, we will describe by this name the triceps cruris of the older anatomists, and the anterior rectus of the thigh.

marked by tendinous intersections ; its inferior extremity is enveloped by a vast aponeurotic cone.

Attachments.—It originates, by its two superior branches, from the imprints which surmount, forwards and outwards, the lip of the cotyloid cavity. It terminates, by its inferior extremity, on the anterior face of the patella.

Relations.—Externally, internally, and posteriorly, with the two other portions of the triceps ; anteriorly, with the tensor of the fascia lata. Its superior extremity, included between the iliacus and the deep gluteus, is separated from the coxo-femoral capsule by a little adipose cushion, which is insinuated between its two branches.

Action.—An extensor of the leg and flexor of the thigh.

B. Vastus Externus (Fig. 201, 11).—*Form—Extent—Situation.*—This is a thick and wide muscular mass, flattened on each side, extending from the superior extremity of the femur to the patella, and situated to the outer side of the rectus femoris.

Structure and Attachments.—The fasciculi composing this muscle are intermixed with strong aponeurotic layers, and originate from the whole outer surface of the femur and the external half of its anterior face ; they are directed forwards and downwards, to terminate either on the anterior rectus, or on the superior face and external side of the patella.

Relations.—Outwardly, with the fascia lata and superficial gluteus ; inwardly, with the rectus femoris and the vastus internus, which is intimately confounded with it except towards the superior extremity of the femur, where the two muscles are distinctly separate ; behind, with the femur and the posterior portion of the superficial gluteus.

Action.—It is an extensor of the leg.

C. Vastus Internus (Figs. 195, 7 ; 203, 17).—This muscle is not very distinct from the preceding for the greater part of its extent, and forms with it a deep and wide channel, in which the rectus femoris is lodged. It is a repetition of the vastus externus, in so far as its form, structure, extent, attachments, and action are concerned ; but it possesses the following peculiarities :—

The fibres entering into its composition arise from the whole internal face and the inner half of the anterior face of the femur, and are inserted, some on the aponeurosis of the rectus femoris, others on the internal patellar ligament, the corresponding side of the patella, and on the superior face of the same bone, in common with the vastus externus.

Relations.—By its external face, to the latter muscle and the rectus femoris ; by its internal face, to the internal crural aponeurosis, the long adductor of the leg, the iliacus, pectineus, and to the long branch of the great adductor of the thigh.

3. Anterior Gracilis (Crureus, Rectus Parvus) (Figs. 197, 6 ; 203, 15).

Synonyms.—Gracilis anterius—*Rigot.* Ilio-femoral gracilis—*Girard.* (*Crureus vel cruralis —Percivall.*)

A small cylindrical muscle, situated in front of the capsule of the coxo-femoral articulation, alongside the fibrous fasciculus that strengthens the anterior portion of this membranous ligament.

Attachments.—It originates from the ilium, very near, and to the outside of, the external branch of the rectus femoris; it afterwards insinuates itself between the two vasti, and terminates on the anterior aspect of the femur by aponeurotic fasciculi.

Relations.—This muscle is included between the three portions of the triceps and the capsular ligament of the coxo-femoral articulation, to which it strongly adheres.

Action.—It appears to raise (or render tense) the capsular ligament during flexion of the femur.

B. Posterior Crural Region.

This region is constituted by three muscles situated behind the thigh. These are the *biceps femoris*, the *semitendinosus*, and the *semimembranosus*.

Preparation.—Place the subject in the second position, allow one hind leg to lie unfastened, and incline the body to the corresponding side, leaving the other limb attached to the supporting bar, with the thigh slightly flexed to make these muscles tense. These preliminary arrangements being adopted, proceed in the following manner: 1. Make a transverse incision through the short adductor of the thigh, and turn back the two portions to the right and left, so as to expose the whole of the semimembranosus, which is to be afterwards dissected from the semitendinosus and the great adductor of the thigh. 2. After removing the aponeurosis covering the biceps femoris and the semitendinosus, the latter is to be dissected by circumscribing as carefully as possible its two superior insertions. 3. The biceps is then to be prepared. The biceps femoris and semitendinosus can be easily dissected in a limb arranged as in Fig. 192.

1. Biceps Femoris (Triceps Abductor Femoris) (Figs. 193, 5; 194, 7).

Synonyms.—Ischio-tibialis externus—*Girard.* A portion of the long vastus—*Bourgelat, Lafosse, Rigot.* (The *biceps abductor femoris* of Percivall. *Anterior pubio-ischio-tibialis—Leyh.*)

Situation—Extent—Direction.—This muscle is situated behind the thigh and the glutei muscles, and extends from the sacral spine to the superior extremity of the leg.

Form and Structure.—It is narrow at its upper extremity, and very wide and thin inferiorly.

Its muscular fibres are partly attached, by their superior extremities, to a longitudinal aponeurotic layer, which gives the muscle a penniform appearance; they terminate, inferiorly, in a strong aponeurosis united to that of the fascia lata.

Attachments.—It arises, above, from the crest of the ischial tuberosity, where the aponeurosis which gives it its penniform appearance is inserted.

Its terminal aponeurosis is spread over the tibial muscles to constitute the fascia of the leg, and is inserted into the tibial crest.

Relations.—The gluteal aponeurosis, in the portion where it becomes semi-elastic, adheres to the external surface of the biceps femoris. In front, the muscle is related to the posterior portion of the superficial gluteus; behind, to the semitendinosus; within, to the external muscles of the leg and the sciatic nerves.

Action.—It flexes the leg and renders tense the tibial fascia, when its fixed point is the pelvis. It rocks the pelvis on the femur when the leg is fixed.

2. Semitendinosus (Biceps Rotator Tibialis) (Figs. 193, 5′; 194, 10).

Synonyms.—Ischio-tibialis medius or posticus—*Girard.* (*Posterior sacro-ischio-tibialis—Leyh.* Percivall describes this and the next muscle by the name of *adductor tibialis.*)

Situation—Extent—Direction.—This muscle is situated behind the preceding and the superficial gluteus, and extends from the sacral spine to the leg, describing a curve, the convexity of which is posterior.

Form—Structure.—It is elongated from above to below, bifid at its superior extremity, thick and prismatic, but nevertheless flattened on both sides. Its muscular fibres are of a pale-red colour, are parallel to each other, and follow the general direction of the muscle; they terminate, inferiorly, on an aponeurosis, by a flat tendon. In its middle portion, the body shows traces of the intersection which has obtained for this muscle the name—*semitendinosus*, in Man.

Attachments.—This muscle arises, above, by one of its branches, from the sacral spine and the sacro-sciatic ligament, in common with the posterior portion of the superficial gluteus, with which it exchanges some fibres;[1] by the other branch, which is the shortest, from the ischial tuberosity. Its inferior aponeurosis is confounded with that of the tibia; the tendon glides over the internal surface of the tibia, and is inserted into its anterior crest.

Relations.—Its sacro-sciatic branch is covered by the gluteal aponeurosis, and covers the superficial gluteus. For the remainder of its extent, it is related: posteriorly, to that aponeurosis; anteriorly, to the sciatic nerves; externally, to the superficial gluteus and gastrocnemius; internally, to the semimembranosus and the great adductor of the thigh.

Action.—It is a flexor of the leg, and tensor of the tibial aponeurosis, when its fixed point is above; when the leg is fixed, it becomes one of the active agents in *rearing*.

3. Semimembranosus (Adductor Magnus) (Figs. 193, 6; 194, 10; 195, 13).

Synonyms.—Ischio-tibialis internus—*Girard.* (*Great ischio-femoralis—Leyh*).

Situation—Volume—Extent—Direction.—Situated within the semitendinosus, and shorter and thinner than it, the semimembranosus extends from the ischium to the inferior extremity of the femur, and follows an oblique direction downwards and forwards.

Form—Structure.—Elongated vertically, flattened on each side, prismatic, thick at its anterior, and very thin at its posterior borders. It is also voluminous at its upper extremity, which has a small prolongation, the point of which ascends to the base of the tail; it is contracted, and terminated by a short tendon, at its inferior extremity. It is formed of thick muscular fasciculi, which all terminate, below, on the terminal tendon.

Attachments.—Above: 1. To the aponeurosis of the coccygeal muscles, by the thin prolongation from its superior extremity. 2. To the ischial tuberosity, and the inferior face of the ischium. Below, to the small eminence situated within the internal condyle of the femur.

Relations.—Inwards, with a very thin prolongation from the gluteal aponeurosis, and with the ischo-cavernous muscle and short adductor of the leg; outwards, with the semitendinosus, the biceps femoris, and the sciatic nerves; in front, with the great adductor of the thigh, which is so intimately united to it that some difficulty is experienced in separating their fibres.

Action.—It is an adductor of the limb and an extensor of the thigh, when its fixed point is above; but when the femur is fixed, it is an auxiliary in *rearing*.

[1] The portion of this muscle which is attached to the sacral spine, certainly represents the most inferior part of the superficial gluteus of Man.

C. Internal Crural Region.

This region comprises nine muscles, applied in three superposed layers against the inner aspect of the thigh. These are: the *long* and *short adductor of the leg*, forming the superficial layer; the *pectineus* and the *small* and *great adductors of the thigh*, forming the middle layer. Those of the deep layer—that is, the *quadrate crural* (*quadratus femoris*), *external obturator*, *internal obturator*, and *gemilli of the pelvis*—are not all situated on the inner face of the femur, one of them being contained within the pelvic cavity. With these muscles—which do not present a very considerable volume—another region might be formed and designated the *deep pelvi-crural*, or *coxo-femoral* region.

Preparation.—1. Place the subject in the first position. 2. Prepare on one side the two muscles of the superficial layer, by removing the slight fibrous layer covering them, the internal crural aponeurosis, and the inferior parieties of the abdomen. 3. To expose, on the opposite side, the three muscles of the middle layer, cut through the two adductors of the leg, and turn them back to the right and left; separate the semimembranosus from the great adductor of the thigh; it may be even useful, in order to study the latter muscle, to remove the entire mass of the three ischio-tibial muscles. 4. Dissect the small deep muscles on a separate piece, as shown in Figs. 195 and 197.

First Layer.

1. Long Adductor of the Leg (Sartorius) (Figs. 195, 8; 201, 15).

Synonyms.—Sublumbo-tibialis—*Girard.* (*Internal ilio-rotuleus—Leyh.*)

Form—Situation—Direction.—This muscle is long, thin, and flattened, narrow at its inferior extremity, and situated at first within the abdominal cavity, at the entrance to the pelvis; afterwards, inside the thigh; it is oblique from above to below, behind to before, and within to without.

Structure.—It is formed of parallel muscular fibres, which extend from its superior to its inferior border; and it terminates, inferiorly, by an aponeurosis which is confounded with that of the short adductor.

Attachments.—It originates, superiorily, from the inferior face of the iliac fascia, near the tendon of the psoas parvus; and it is inserted, by means of its terminal aponeurosis, not on the supero-internal tuberosity of the tibia, but on the internal patellar ligament, in common with the short adductor.

Relations.—It is covered by the crural aponeurosis and Poupart's ligament, and covers the iliacus, psoas magnus, the anterior femoral nerve, and the vastus internus. Superiorly, its inner border forms the limit—with the pectineus and the anterior border of the short adductor—to a triangular space occupied by the crural vessels; below this space, the two adductors of the leg are closely adherent to each other.

Action.—It adducts the leg, and flexes the femur.

2. Short Adductor of the Leg (Gracilis) (Fig. 195, 9).

Synonyms.—Subpubio-tibialis—*Girard.* (*Pubio-tibialis—Leyh.*)

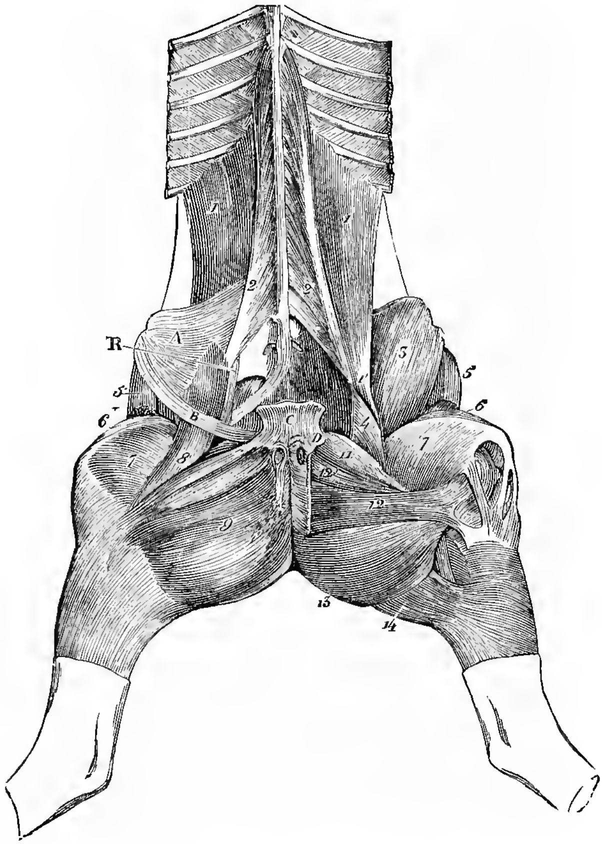
Form—Situation—Direction.—A large quadrilateral muscle, thin at its borders, situated inside the thigh in an oblique direction downwards and outwards. It forms the base of what is called the *flat of the thigh.*

Structure.—Formed of parallel muscular fibres, which extend from its superior to its inferior border, this muscle is tendinous at its origin, is covered by an albugineous layer, and terminates inferiorly in a wide aponeurosis.

Attachments.—It originates, by the whole extent of its superior border, from the under surface of the ischio-pubic symphysis, and is united to the muscle of the opposite side—*origin.* Its terminal aponeurosis, united to that of the sartorious, is inserted on the internal patellar ligament and the internal face of the tibia—*movable insertion;* posteriorly, it is united to the aponeurosis of the semitendinosus, and with it forms the tibial aponeurosis enveloping the tibial muscles.

Relations.—Its superficial face is covered by a cellulo-fibrous layer, and by the saphena vessels and nerves. It covers, by its deep face the pectineus, the

Fig. 195.



MUSCLES OF THE SUBLUMBAR, PATELLAR, AND INTERNAL CRURAL REGIONS.

1, Psoas magnus; 1′, its terminal tendon; 2, psoas parvus; 3, iliacus; 4, its small internal portion; 5, tensor of the fascia lata; 6, rectus femoris; 7, vastus internus; 8, sartorius; 9, gracilis; 11, pectineus; 12, adductor magnus; 12′, adductor parvus; 13, semimembranosus; 14, semitendinosus. A, Portion of the iliac fascia; B, portion of the layer reflected from the aponeurosis of the obliquus abdominis externus, forming Poupart's ligament; C, pubic tendon of the abdominal muscles; D, origin of the pubio-femoral ligament.

adductors of the thigh, the semimembranosus and semitendinosus, and the internal femoro-tibial ligament. It is traversed at its origin, and altogether in front, by a very large vein.

Action.—An adductor of the limb and a tensor of the tibial aponeurosis.

Second Layer.

3. Pectineus (Fig. 195, 11).

Synonyms.—Superpubio-femoralis—*Girard.* Its anterior branch corresponds to the pectineus, and the posterior to the middle adductor, in Man. (*Anterior pubio-femoralis—Leyh.*)

Situation—Direction—Form.—Situated beneath the preceding, in an oblique direction downwards, forwards, and outwards, this muscle is conoid, thick, and bifid at its superior extremity, contracted at its inferior extremity.

Structure and Attachments.—Its fasciculi arise either from the anterior border and inferior surface of the pubis, or from the surface of the pubio-femoral ligament, which passes between its two branches—*fixed insertion.* They are enveloped, at their inferior extremity, by a tendinous cone, which is attached, on the inner aspect of the femur, to the imprints surrounding the nutrient foramen—*movable insertion.*

Relations.—Inwards, with the short adductor of the leg; outwards and forwards, with the femoral insertion of the psoas magnus and iliacus, the vastus internus, the crural vessels, and the sartorius; behind, with the gracilis, and, near its superior extremity, with the obturator externus.

Action.—This muscle is an adductor and flexor of the thigh, and more particularly a rotator inwards of the same femur.

4. Small Adductor of the Thigh (Adductor Parvus, Adductor Brevis) (Figs. 195, 12′; 203, 14).

Synonyms.—The anterior portion of the biceps femoralis of Bourgelat, and of the subpubio-femoralis of Girard.[1] (*Middle pubio-femoralis* of Leyh. A portion of the *adductores femoris* of Percivall, and which he has named the *adductor brevis.*)

Situation—Direction.—Situated beneath the gracilis, between the pectineus and the adductor magnus; it passes in an oblique direction downwards and outwards.

Form—Structure.—It is flat from before backwards, thick and narrow at its upper extremity, thin and wide inferiorly. Its muscular fibres are of a pale-red colour, nearly parallel to each other, and sometimes very indistinct—superficially, at least—from those belonging to the adductor magnus; inferiorly, they become aponeurotic.

Attachments.—Above, to the inferior face of the pubis—*origin;* below, to the roughened quadrilateral surface on the posterior and middle aspect of the femur, in common with the short branch of the adductor magnus—*termination.*

Relations.—Inwards, with the gracilis; outwards, with the obturator externus; in front, with the pectineus; behind, with the adductor magnus.

5. Great Adductor of the Thigh (Adductor Magnus, Adductor Longus) (Fig. 195, 12)

Synonyms.—Posterior portion of the biceps femoralis of Bourgelat, and of the subpubio-femoralis of Girard. (*Posterior pubio-femoralis—Leyh.*)

Situation—Direction.—The great adductor is situated beneath the preceding

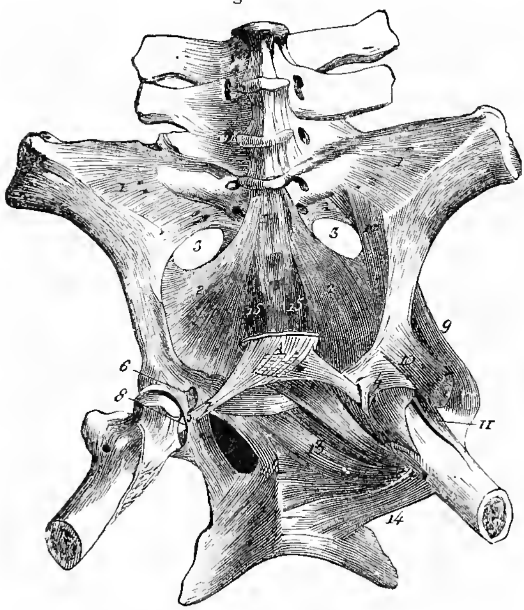
[1] After mature deliberation, we have decided on describing as two muscles the biceps femoralis of Bourgelat, and to give to them the names of small and great adductors of the thigh, by which Bichat has designated the corresponding muscles in the lower extremity of Man. We have thought it our duty, in this instance, to follow the example given us by several German authors.

muscle, between the small adductor and the semimembranosus, proceeding obliquely downwards and outwards.

Form—Structure.—It is a long, thick, prismatic muscle, flat before and behind, terminating, inferiorly, by two branches of unequal length, and almost entirely composed of parallel muscular fibres, which are generally distinguished from the fasciculi of the small adductor by their deeper colour.

Attachments.—Above, to the lower face of the ischium and to the single tendinous band which attaches the two muscles of the flat of the thigh to the pelvic symphysis — *origin.* Below: 1. By its external branch, the thickest and shortest, to the quadrilateral scabrous surface on the posterior face of the femur, outside the small adductor. 2. By its internal branch—the longest and thinnest—to the supero-internal condyle of the femur, in common with the semimembranosus and the internal femoro-tibial ligament —*termination.*

Fig. 196.



DEEP MUSCLES OF THE COXO-FEMORAL REGION.

9, Deep gluteus, 10, origin of the rectus femoris; 11, rectus parvus; 13, obturator externus, 14, quadratus femoris; 15, depressor coccygis.

Relations.—Inwards, with the short adductor of the leg; behind, with the semimembranosus; in front, with the small adductor, the external obturator, and the inferior extremity of the quadratus femoris. Its external border, thinner than the internal, partly covers the superior extremity of the latter muscle, and is separated from the sciatic nerves and the biceps femoris by an aponeurotic layer. The crural vessels pass between its two branches, one of which, the internal, is related anteriorly and near its insertion to the vastus internus.

Action.—This muscle is an adductor and extensor, as well as a rotator outwards of the femur.

Third Layer.

6. Quadrate Crural (Quadratus Femoris, Ischio-Femoralis) (Figs. 196, 14; 197, 10).

Synonyms.—The gracilis internus of Bourgelat, and the ischio-femoral gracilis of Girard. (Not described by Percivall. *Small ischio-femoralis* of Leyh. The *quadratus femoris* of Man.)

Situation—Direction—Form—Structure.—Situated on the posterior face of the femur, between the great adductor and external obturator, and oblique downwards and outwards, the quadratus femoris is a small flat band, formed of parallel muscular fibres, slightly tendinous at their inferior extremity.

Attachments.—Above, to the inferior surface of the ischium, in front of the ischial tuberosity—*origin; terminating*, below, on the linear imprint on the posterior face of the femur, a little below the trochanter internus (Fig. 197, 10).

Relations.—In front with the posterior face of the femur and external obturator. Behind, and inwardly, with the adductor magnus. Outwards, with the sciatic nerves and the gemellus posticus.

Action.—It is an extensor and adductor of the femur. In our opinion, its mode of attachment will not permit it to rotate this bone either inwards or outwards—at least in Solipeds.

7. Obturator Externus (Fig. 196, 13).

Synonym.—Subpubio-trochanterius externus—*Girard.*

Form—Structure—Situation—Direction.—A short, thick, flat muscle, triangular, fasciculated, fleshy and aponeurotic, very delicate in texture, and placed almost horizontally beneath the pelvis, at the margin of the obturator foramen, which it covers, and from which it derives its name of *obturator*.

Attachments.—1. To the inferior surface of the pubis and ischium, by the internal extremities of its fasciculi—*fixed insertion*. 2. To the trochanteric fossa, by the external extremities of these fasciculi—*movable insertion*.

Relations.—Inferiorly, with the pectineus, the two adductors of the thigh, and the quadratus femoris; superiorly, with the capsule of the hip-joint, and the internal obturator.

Action.—An adductor and rotator outwards of the thigh.

8. Obturator Internus (Figs. 196, 197).

Synonym.—Subpubio-trochanterius internus—*Girard.*

Situation.—This muscle is situated in the pelvic cavity, above the oval foramen, and is, consequently, opposite the external obturator.

Form—Structure—Attachments.—It is formed of two portions. One is very thin, and composed of slightly tendinous, divergent muscular fasciculi, which arise from around the obturator foramen, are directed outwards, and terminate in a tendon belonging to the other portion. The latter, elongated and penniform, is situated in the pelvis, and extends from the anterior angle of the sacrum to the inferior extremity of the femur, following the direction of the ischial border of the ilium, into which it is inserted. The tendon to which it owes its penniform shape is inflected outwards, behind the supra-cotyloid crest or sciatic ridge, joins the gemelli, and terminates in the bottom of the trochanteric fossa.

Relations.—In its intra-pelvic portion, this muscle responds: outwards and downwards, to the ilium, pubis, ischium, and external obturator; inwards and upwards, to the peritoneum, important vessels and nerves, and to a fibrous layer that separates it from the bladder. In its extra-pelvic portion, it is in relation with—behind, the middle gluteal muscle and the sciatic nerves; in front, with the gemelli. A synovial sheath facilitates the gliding of its tendon in the groove in which it turns.

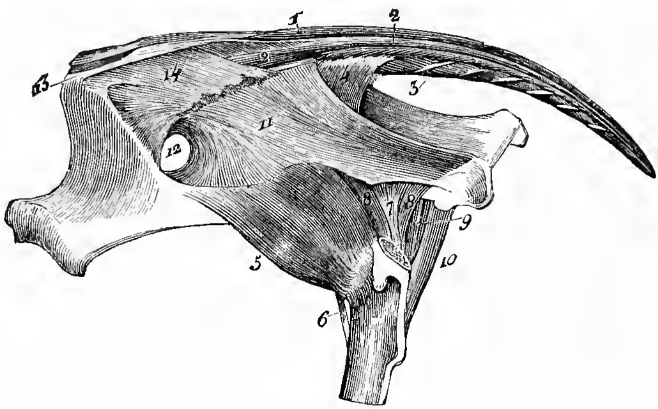
Action.—It is a rotator of the thigh outwards, and, contrary to the opinion of the majority of authors, we believe it to produce abduction rather than adduction, if at any time its position allows it to execute either of these two movements.

9. Gemelli (Fig. 197, 8, 8, 9).

Synonyms.—Ischio-trochanterius—*Girard.* (*Gemini—Percivall. Bifemoro-calcaneus—Leyh.*)

The two small muscles which receive this name are far from presenting the same arrangement in every subject; but we will describe that which appears to be the most frequent. Two little elongated muscular fasciculi are usually found, one above, the other below, the tendon common to the two portions of the obturator internus. These two fasciculi (Fig. 197, 8, 8), arise from the external border of the ischium, follow the direction of the above-mentioned tendon, and are inserted into it by the external extremities of their fibres, exactly representing the gemelli of Man. But there is also a third (Fig. 191, 9), wide, flat, and often

Fig. 197.



COCCYGEAL AND DEEP MUSCLES SURROUNDING THE COXO-FEMORAL ARTICULATION.

1, Erector coccygeus; 2, curvator coccygeus; 3, depressor coccygeus; 4, compressor coccygeus; 5, deep gluteus; 6, rectus parvus; 7, tendon of the internal obturator; 8, 8, gemelli; 9, accessory fasciculus of the gemelli; 10. quadratus femoris; 11, sacro-sciatic ligament; 12, great sacro-sciatic foramen; 13, superior ilio-sacral ligament; 14, inferior ilio-sacral ligament.

very voluminous, situated between the preceding and the obturator externus; it is attached, by its inner border, to the external border of the ischium, contracting intimate adhesions with the other two and with the tendon of the obturator internus, and becoming inserted by the whole extent of its external border into the trochanteric fossa.

Relations.—Posteriorly, to the sciatic nerves; anteriorly, to the capsule of the hip-joint and the obturator externus, through the medium of an adipose cushion.

Action.—Like the preceding muscle, these rotate the thigh outwards, and perhaps tend to produce its abduction.

Differential Characters in the Muscles of the Thigh in the other Animals.

1. Anterior Crural Region.

In the **Ox, Sheep,** and **Goat,** the *tensor* of the *fascia lata* is much wider than in Solipeds; that of the **Camel** is so developed that it completely envelops the *triceps cruralis.* In the

Dog and **Cat,** the same muscle shows, in front, a supernumerary fasciculus—a thick and long strip mixed inwardly with the sartorius, and extending vertically from the external angle of the ilium to the patella, into which it is inserted by a short aponeurosis.

The *rectus femoris*, in the **Dog** and **Sheep,** has only one branch of origin.

The *rectus parvus*, that very thin muscle, does not exist in Solipeds and Carnivora.

2. Posterior Crural Region.

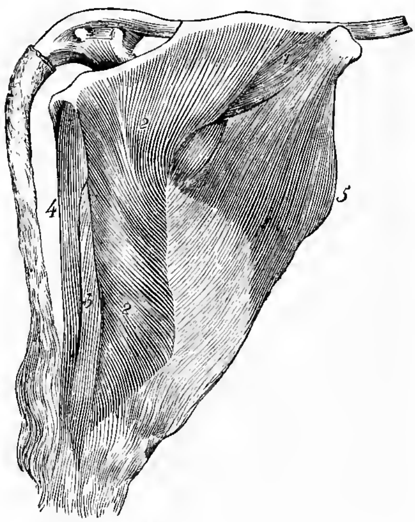
A. **Ruminants.**—In the *Ox*, *Sheep*, and *Goat*, the *biceps femoris* is but little distinct from the posterior portion of the superficial gluteus. It is longer and paler than in the Horse, and its fibres are not penniform as in Solipeds.

The *semitendinosus* has no sacral prolongation: it arises only from the ischium.

The *semimembranosus* is divided, inferiorly, into two branches: one, very thick, passes to the femur; the other, much smaller, terminates by a tendon which is insinuated beneath the internal lateral ligament of the femoro-tibial articulation, to gain the superior extremity of the tibia.

In the *Camel*, an important peculiarity should be noticed. In the posterior crural region is found an elastic apparatus resembling that in the anterior limb of this animal. This is in the form of a thick fascia, which descends from the supra-spinous ligament and the aponeurotic sheath of the coccygeal muscles, is attached to the ischial tuberosity, largely covers the space between the biceps femoris and semitendinosus, crosses the sinus of the femoro-tibial angle, and lies on the retaining aponeurosis of the popliteus and lateral extensor of the phalanges. Here it divides into two portions: the smaller is composed of fasciculi a little apart, which pass backwards and mix with similar fasciculi from the inner surface of the thigh, and become attached to the tendon of the gastrocnemius; the larger portion descends in front of the tarsus and metatarsus, and terminates towards the lower third of that bone, on the surface of the extensor tendons of the digits. The use of this elastic layer is to flex all the articulations of the abdominal limb in a passive manner.

Fig. 198.



SUPERFICIAL MUSCLES OF THE CROUP AND THIGH IN THE COW.

1, Middle gluteal; 2, 2, biceps femoris, anterior portion; 3, ditto, posterior portion; 4, semitendinosus; 5, tensor of the fascia lata.

The *biceps femoris* in the Camel resembles that of the Horse.

The *semitendinosus* is narrow in the middle, where it has an aponeurotic tint.

The *semimembranosus* is thicker than the last-mentioned, but, like it, it is constricted in the middle and expanded at its inferior extremity. It is attached, by its muscular fibres, to a salient ridge above the internal condyle of the femur, and, by a short fibrous layer, to the internal femoro-tibial ligament.

B. **Pig.**—The *biceps femoris* of this animal is arranged like that of the Sheep.

The *semitendinosus* and *semimembranosus* have a small point that ascends towards the root of the tail, and represents the sacro-sciatic branch of these two muscles in Solipeds.

C. **Carnivora.**—In these animals, the *biceps femoris* proceeds from the ischium, and divides, inferiorly, into two unequal branches: an anterior, the largest, terminates by an aponeurosis which goes to the external patellar ligament and tibial crest; and a posterior, attached to the tibial aponeurosis above and external to the gastrocnemius tendon.

The *semitendinosus* and *semimembranosus* are as in the smaller Ruminants.

3. Internal Crural Region.

A. **Ruminants.**—The *sartorius* in the *Ox* and *Sheep* is traversed, near its origin, by the femoral artery. In the *Camel*, the *gracilis* is bifid; the anterior branch is the smallest. The *pectineus* of the *Ox*, single at its upper extremity, is divided into two branches at its inferior extremity. One of these branches, thin and pale, is prolonged to near the internal condyle of the femur, while the principal stops, as in the Horse, on the posterior face of the bone.

The *adductor parvus* is scarcely distinct from the *adductor magnus*. The latter is undivided at its inferior extremity, which stops at the posterior face of the femur, without going to the inner condyle of that bone.

The *obturator internus* has no upper portion; it is united to the obturator externus in passing through the obturator foramen.

B. **Pig.**—In this animal, the internal crural muscles offer somewhat the same arrangement as in the Ox.

C. **Carnivora.**—In the *Dog* and *Cat*, the *sartorius* arises from the external angle of the ilium, and by its muscular portion is prolonged to the inner face of the tibia. The *gracilis* is much thinner and narrower than in the other animals. The *adductor parvus* is a little, distinct muscle, which begins on the inferior face of the pubis, and terminates at the posterior face of the femur, below the quadratus femoris. The *adductor magnus* is, on the contrary, a wide, thick, undivided muscle, attached to nearly the whole extent of the linea aspera of the femur.

There is nothing particular to note with regard to the *quadratus femoris* and the *obturators*; the *gemelli* are always composed of two small, distinct fasciculi, which comport themselves as in Man.

Comparison of the Muscles of Man's Thigh with those of the Thigh of Animals.

The muscles of the thigh in Man are divided into three regions, as in animals.

1. Anterior Muscles.

The *rectus parvus* is not found in *Man;* nevertheless, there are reckoned three anterior muscles of the thigh, because the *sartorius*, which corresponds to the sartorius of animals, is included in this region.

The *sartorius* is a very long muscle, the width of which at most is about two fingers' breadth. It is attached above, not to the lumbo-iliac aponeurosis, but to the anterior and superior iliac spine; it is afterwards directed downwards and inwards, to pass round the internal condyle of the femur, and terminate by an expanding tendon at the crest of the tibia.

The *tensor of the fascia lata* shows the same general arrangement observed in animals. It is the same with the *triceps femoris*. The *rectus femoris* arises by two tendinous branches: one is detached from the anterior and inferior iliac spine; the other from the brim of the cotyloid cavity.

2. Muscles of the Posterior Region.

These are three in number: the femoral or crural biceps, semitendinosus, and semimembranosus.

The *biceps femoris* is represented in Solipeds by the posterior portion of the biceps femoris. It is an elongated muscle arising by two heads: the long head comes from the ischiatic tuberosity; the shortest from the middle of the linea aspera. After their union, these two heads give rise to a tendon which is fixed into the head of the fibula, and sends an expansion over the tibial aponeurosis.

The *semitendinosus* arises in common with the long head of the biceps; its inferior tendon is reflected beneath the internal tuberosity of the tibia, to be fixed into the crest of that bone. This tendon, with that of the sartorius, forms the aponeurotic expansion called the *goose's foot.*

The *semimembranosus* is voluminous in its lower portion, and arises, like the other two, from the tuberosity of the ischium; its fibres pass to a tendon which, on reaching the inner side of the knee, terminates in the three pieces composing that articulation (see Fig. 200).

3. Muscles of the Internal Region.

In books on human anatomy, these muscles are sometimes designated, from their action, by the generic name of *adductors*. They comprise: the internal rectus, pectineus, first or middle adductor, second or small adductor, and third or great adductor. The square crural, the obturators, and the gemelli are described among the posterior muscles of the pelvis. They will, however, be briefly alluded to here.

The *internal rectus* corresponds to the gracilis of animals. It is a thin muscle, bordering the inner side of the thigh. It is attached, above, to the symphysis pubis; below, to the crest of the tibia, in common with the sartorius tendon.

The *pectineus* repeats the anterior branch of the pectineus of the Horse. It is inserted, below, into the internal bifurcation of the linea aspera of the femur.

The *first adductor* corresponds to the posterior branch of the pectineus of Solipeds. It is represented by a voluminous muscular mass, which arises from the spine of the pubis and terminates on the middle third of the linea aspera.

The *second* or *small adductor* corresponds to the muscle of the same name in animals. It is inserted into the same points as the preceding.

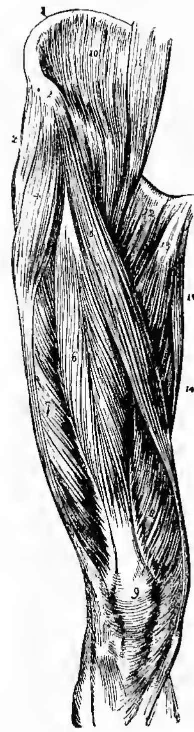
The *third* or *great adductor* is attached, above, to the ischiatic tuberosity and to the whole

Fig. 199.

MUSCLES OF THE ANTERIOR FEMORAL REGION IN MAN.

1, Crest of the ilium; 2, its antero-superior spinous process; 3, gluteus medius; 4, tensor vaginæ femoris; 5, sartorius; 6, rectus; 7, vastus externus; 8, vastus internus; 9, patella; 10, iliacus internus; 11, psoas magnus; 12, pectineus; 13, adductor longus; 14, portion of adductor magnus; 15, gracilis.

Fig. 200.



MUSCLES OF THE POSTERIOR FEMORAL AND GLUTEAL REGION IN MAN.

1, Gluteus medius; 2, gluteus maximus; 3, vastus externus, covered by fascia lata; 4, long head of biceps; 5, short head; 6, semitendinosus; 7, 7, semi-membranosus; 8, gracilis; 9, portion of inner border of adductor magnus; 10, edge of sartorius; 11, politeal space; 12, gastrocnemius, with its two heads.

of the lower branch of the ischium by aponeurotic fibres. It afterwards divides into two branches: the external branch, entirely muscular, is fixed into the entire interspace of the linea aspera; the internal branch gives rise to a tendon which goes to the inner condyle of the femur. Between these two branches is found, as in the Horse, the *ring of the adductors*, in which pass the large vessels of the thigh.

The *quadratus femoris* of Man is nearly horizontal, as it is attached, inwardly, to the external border of the ischium, and outwardly, between the great and small trochanters.

The *obturator internus* and *gemelli* resemble those of the Dog.

Muscles of the Leg.

These muscles, nine in number, are grouped around the two principal bones of the leg, so as almost to completely envelop them, leaving only the internal face of the tibia uncovered. Like those of the forearm, they form two particular regions : an *anterior* and a *posterior ;* and they are sheathed in common by the *tibial aponeurosis*—a very solid fibrous covering, which in every respect corresponds to the antibrachial aponeurosis.

Tibial Aponeurosis.

This aponeurosis is formed of several superposed layers which are intimately united, and receives, superiorly, the insertion of the biceps femoris, the semitendinosus, and the gracilis, which may be considered as its tensor muscles.

It is continued, inferiorly, over the tarsus and the metatarsal region, in becoming singularly attenuated, and in covering the fibrous bands which bind and retain the anterior tibial muscles in the bend of the hock. Its external surface is separated from the skin by a very thin fibrous expansion ; its internal face furnishes special and very firm sheaths around the majority of the tibial muscles.

The tibial aponeurosis is attached to the internal surface and crest of the tibia, as well as to the summit of the calcis. The latter attachment takes place by a thick fibrous band, the singular and complicated arrangement of which has not yet been exactly described. It is situated in front of the *tendon of the gastrocnemius*, or between that tendon and the deep layer of the posterior tibial muscles. By its borders, it is continuous with the tibial aponeurosis or fascia. Superiorly, it adheres most intimately to the perforatus tendon, near the point where the latter originates ; then it sends off a thick fasciculus that descends to the gastrocnemius tendon. Below this, it appears to divide into two branches—an external and internal—which are united to the calcanean cap of the perforatus tendon, and are attached to the sides of the os calcis in such a manner, that near its insertion the gastrocnemius tendon is found to be enveloped by a complete fibrous sheath, formed partly by the perforatus tendon and partly by the band just described. This latter, therefore, constitutes a strengthening apparatus for the tendon of the gastrocnemius—a structure noticed by Girard, who made it a branch of insertion of the semitendinosus ; and not without reason, perhaps, because it arises from the tibial aponeurosis, which, in part at least, is itself derived from the semitendinosus muscle.

Preparation of the Muscles of the Leg.—Separate the limb from the trunk by sawing through the femur at its middle. Dissect the insertions of the superficial gluteus, the biceps femoris, the gracilis, and the semitendinosus, to observe the continuity of these muscles with the tibial aponeurosis: study the insertions of this aponeurosis, particularly that which it has on the summit of the os calcis. To expose the muscles, remove their aponeurotic envelope, leaving, however, the band it forms in front of the tendon of the gastrocnemius, as well as the bands which retain the tendons. Remove the hoof in the manner already indicated for the anterior extremity, and, finally, separate the muscles from one another—an operation so very simple as not to require any special directions.

A. Anterior Tibial Region.

This is composed of three muscles : the *flexor of the metatarsus*, the *anterior extensor*, and the *lateral extensor of the phalanges*. The first is deep-seated, the other two are superficial.

1. ANTERIOR EXTENSOR OF THE PHALANGES (EXTENSOR PEDIS) (Fig. 201, 20).

Synonyms.—Femoro-prephalangeus—*Girard.* The extensor longus digitorum pedis of Man.

Situation—Direction—Extent.—This muscle, situated in front of the leg and foot, follows the direction of these two sections for their whole extent.

Form—Structure.—It is formed of a muscular body and a tendon. The first

Fig. 201.

EXTERNAL DEEP MUSCLES OF RIGHT POSTERIOR LIMB.

1, Crest of the ilium; 2, inferior sacro-sciatic ligament; 3, sacro-sciatic ligament; 4, obturator ligament; 5, tuberosity of the ischium; 6, anterior tuberosity of the ilium; 7, deep gluteus; 8, its insertion into the great trochanter, 9; 10, iliacus; 11, vastus externus; 12, rectus femoris; 13, great sciatic nerve; 14, gracilis; 15, sartorius; 16, patella; 17, lateral ligament; 18, oblique flexor of the phalanges, or flexor pedis accessorius; 19, peroneus; 20, extensor pedis; 21, soleus, or plantaris; 22, gastrocnemius; 23, flexor pedis; 24, tendon of oblique flexor of the phalanges; 25, perforatus tendon; 26, lateral ligament of perforatus tendon; 27, 28, annular ligament; 29, tendon of lateral extensor of the phalanges, or peroneus; 30, external rudimentary metatarsal bone

is fusiform, flat on each side, aponeurotic at its superficies in its superior moiety, and tendinous internally in its inferior moiety. The tendon, at first round, then flat, commences a little above the inferior fourth of the tibia, and reaches the anterior face of the principal metatarsus, where it receives the extensor brevis, the tendon of the peroneus, and a funicular prolongation of the tibial aponeurosis. It afterwards descends on the fetlock, where it comports itself exactly as the corresponding tendon in the anterior extremity (see the extensor pedis in the fore limb, p. 324).

Attachments.—Above, in the digital fossa between the trochlea and external condyle of the femur, through the medium of the tendinous portion of the flexor metatarsi—*fixed insertion.* Below, on the capsular ligament of the metatarso-phalangeal articulation, the anterior face of the two first phalanges, and the pyramidal process of the os pedis.

Relations.—The muscular portion responds: outwardly, with the tibial aponeurosis; inwardly, to the flexor metatarsi; posteriorly, to the peroneus. The tendon successively covers: the anterior aspect of the tibia, the anterior capsular ligament of the tarsus, the pedal muscle, the anterior face of the principal metatarsal, the articulation of the fetlock, and the two first phalanges. It is covered by the tibial aponeurosis, and by three annular fibrous bands which maintain the tendon in the bend of the hock. One of these bands—the superior—is fixed by its extremities to the tibia, a little above the tibio-tarsal articulation; it is common to the muscle we are describing, and to the flexor metatarsi. The middle band, attached to the cuboid branch of the latter muscle and the inferior extremity of the os calcis, is for the anterior extensor of the phalanges. The inferior maintains the two extensors against the superior extremity of the principal metatarsal.

Action.—This muscle extends the digit and flexes the entire foot.

2. Lateral Extensor of the Phalanges (Peroneus) (Fig. 201, 19).

Synonyms.—Peroneo-prephalangeus—*Girard.* The peroneus brevis of Man. (*Tibio-prephalangeus—Leyh.*)

Situation—Form—Structure—Extent—Direction.—Situated on the external side of the leg, between the preceding and the deep flexor of the phalanges, it is composed of a muscular portion and a tendon. The first, elongated, prismatic, and slightly penniform, extends in the direction of the leg, from the superior extremity of that region to beyond its inferior extremity. The tendon succeeds the lower end of the muscular portion, and traverses the groove on the middle of the infero-external tuberosity of the tibia, passing to the external side of the tarsus, where it is enclosed in a very firm sheath, and is inflected forwards to become united to the tendon of the anterior extensor, near the middle of the metatarsal region.

Attachments.—It is attached, by the superior extremity of its muscular fibres, to the external femoro-tibial ligament, to the whole extent of the fibula, and to the fibrous partition which separates this muscle from the perforans—*origin.* It terminates in the tendon of the anterior extensor.

Relations.—Its muscular body is enveloped in a special containing aponeurosis, which separates it, in front, from the anterior extensor, and behind from the perforans. The tendon covers the tibia, and margins the external and superficial ligament of the tibio-tarsal articulation; this ligament supplies a fibrous ring for the formation of its reflected sheath. A bursa facilitates its motion in the interior of this sheath.

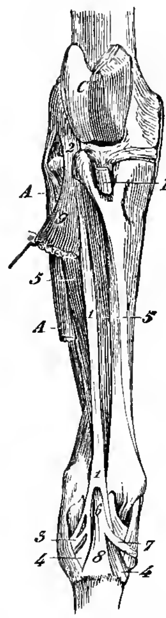
Action.—It acts like the preceding.

3. Flexor of the Metatarsus (Flexor Metatarsi) (Fig. 202).

Synonyms.—Tibio-premetatarsus—*Girard.* Its muscular portion represents the tibialis anticus of anthropotomists.

This muscle is situated beneath the anterior extensor of the phalanges, on the external surface of the tibia, and is composed of two distinct portions—one muscular, the other aponeurotic, not united from end to end, but placed parallel one before the other.

Fig. 202.



FLEXOR METATARSI.

1, Tendinous portion; 2, its attachment to the femur; 3, its cuboid branch; 4, its metatarsal branch; 5, muscular portion; 6, its tendon passing through the ring of the tendinous portion; 7, cuneiform portion of this tendon; 8, its metatarsal branch; 9, anterior extensor of the phalanges drawn outwards by a hook. A, Lateral extensor; B, tibial insertion of the middle patellar ligament; C, femoral trochlea.

A. Tendinous Portion (Fig. 202, 1).—*Course—Attachments.*—This is a strong, pearly-white cord, comprised between the *muscular portion* and the anterior extensor of the phalanges. It commences at the inferior extremity of the femur, in the fossa between the trochlea and the external condyle; it afterwards passes through the superior groove of the tibia, where it is enveloped by a prolongation from one of the synovial membranes of the femoro-tibial articulation, giving origin, below this groove, to the muscular fibres of the anterior extensor of the phalanges. Lower, it receives some of the fasciculi from the muscular portion, to which it sends, in exchange, several aponeurotic layers; it passes under the superior annular band in front of the hock, in company with the anterior extensor, and reaches the level of the trochlea of the astragalus, where it is perforated to form a ring for the passage of the inferior extremity of the muscular portion. It finally terminates in two branches: a large one, inserted in front of the superior extremity of the principal metatarsus (Fig. 202, 4); the other, narrower, deviates outwards to reach the anterior surface of the cuboid bone (Fig. 202, 3).

Relations.—In front, with the anterior extensor of the phalanges; behind, with the muscular portion and the anterior capsular ligament of the tarsus.

Action.—This tendon enjoys the curious property of bending the hock by an action altogether mechanical, whenever flexion of the superior bones of the limb takes place. It is, therefore, a conducting cord which regulates the movements of flexion in the hock, and conforms them to those taking place in the other joints, without requiring the intervention of an active agency for the execution of these movements.

Another function has also been attributed to it—that of passively opposing the flexion of the femur on the tibia while the animal is standing, and in this way serving as an adjunct to the muscular force which supports the weight of the body. But, in our opinion, this is incorrect; as, in order that it may perform this task, it would be necessary for the foot to be maintained in a fixed position by the contraction of its extensor muscles. But these muscles are really the heads of the gastrocnemius, which have their origin behind the femur, and which undoubtedly tend to flex that bone on the tibia—that is, to determine the movement it is supposed to prevent. And experiment clearly shows that we are justified in this opinion; for division of this tendon in the living animal does not interfere in the slightest degree with its natural attitude, either when standing at liberty or when compelled to stand.[1]

B. Muscular Portion.—*Situation—Form—Structure.*—Situated between the tendinous cord and the tibia, this portion is elongated from above to below, very wide at its superior part and narrow inferiorly, where it terminates in a bifid tendon.

Attachments.—It originates, by the upper extremity of its muscular fibres, from the tibia, below and on the sides of the groove through which the tendon passes; its most superficial fibres are even attached to the aponeurotic sheath which envelops the lateral extensor. Its terminal tendon (Fig. 201, 6) traverses the annular ligament which the tendinous portion forms at its inferior extremity, and becomes inserted, by one of its branches, in front of the superior extremity of the principal metatarsal bone, along with the analogous branch of the tendinous division (Fig. 200, 8). The other ramification is directed to the inside of the tarsus, to be attached to the second cuneiform bone (Fig. 202, 7).

Relations.—In front, with the tendinous portion of the muscle and the anterior extensor of the phalanges; behind, with the external face of the tibia. The tendon, after traversing the annular ligament of the cord, covers the metatarsal branch of the latter, and is in turn covered by the anterior extensor.

Action.—It is an active agent in flexing the foot on the leg.

B. Posterior Tibial Region.

This region includes six muscles, which are arranged in two superposed layers behind the tibia. The superficial layer is formed by the *gastrocnemii*, *soleus* or *plantaris*, and the *superficial flexor of the phalanges*. The deep layer is composed of the *popliteus*, the *deep flexor*, and the *oblique flexor of the phalanges*.

[1] J. F. Meckel rightly considers this tendinous cord, not as a portion of the anterior tibial, but as a dependency of the extensor longus digitorum. It would be wrong, however, to describe it apart from the anterior tibial, properly so-called—that is, the muscular portion of our flexor metatarsi, the two being, in their action, essentially one.

Is there anything in the human species analogous to this fibrous cord? After much hesitation, we answer in the affirmative, and give it as our opinion that this tendon represents the *peroneus tertius* in Man. These are our reasons for making this assertion, hazardous as it certainly is at first sight: In Man, the peroneus tertius cannot always be easily distinguished from the extensor longus digitorum; so that these two muscles may be regarded as a single one until reaching the instep, where it extends to the phalanges of the toes on the one part, and the metatarsus on the other. Precisely the same arrangement is found in Solipeds; the single muscle divides into two fasciculi, one for the digital region (*anterior extensor of the phalanges*), the other to the metatarsal region (*tendon* of our *flexor metatarsi*). This tendon, then, exactly represents the fasciculus of the long common extensor of the toes (in Man), which goes to the metatarsus, and is designated the *peroneus tertius.*

But to this it may be said: Your peroneus tertius in the Horse has no relation whatever to the peroneus, and does not this prove that you are in error? No; for if this muscle is attached to the fibula in Man, it is because the principal muscle on which it depends is inserted there itself. But as the anterior extensor of the phalanges of the Horse—that is, the common extensor of the toes—is not inserted into the fibula, and has no connection with it in any way, its metatarsal fasciculus—or rather its tendinous cord or peroneus tertius—ought to be absolutely in the same condition. We repeat, however, that this opinion may be, perhaps, a little hazardous; and we give it with reserve, though we have some reasons for considering it to be correct.

1. Gastrocnemius, or Gemelli of the Tibia (Gastrocnemius Externus) (Figs. 201, 22 ; 203, 20).

Synonyms.—Bifemoro-calcaneus—*Girard.*

Situation—Composition—Extent.—The gemelli of the leg, situated behind the

Fig. 203.

MUSCLES ON INNER ASPECT OF LEFT POSTERIOR LIMB.

1, Crest of the ilium; 2, section through it; 3, sacro-sciatic ligament; 4, pyriformis; 5, posterior portion of sacro-sciatic ligament; 6, tuberosity of ischium; 7, anterior portion of ischium, sawn through; 8, pubis; 9, obturator foramen; 10, external iliac artery and vein, 11; 12, obturator artery and vein (the figures are placed on the internal obturator muscle); 13, long adductor of the leg, or sartorius; 14, small adductor of the thigh, or adductor parvus; 15, short adductor of the leg, or gracilis; 16, rectus of the thigh; 17, vastus internus; 18, patella, with insertion of rectus; 19, upper extremity of tibia; 20, gastrocnemius; 21, popliteus; 22, oblique flexor of the phalanges, or flexor pedis accessorius, with its tendon, 34; 23, perforans muscle, with its tendon, 35; 24, flexor metatarsi; 25, anterior extensor of the phalanges, or extensor pedis; 26, annular ligament; 27, tendon of flexor metatarsi, and its cunean branch, 28; 29, tendon of the superficial flexor of the phalanges; 30, tendon of gemelli or gastrocnemius; 31, os calcis; 32, astragalus; 33, perforatus tendon; 34, tendon of oblique flexor joining the perforans tendon, 35; 36, large metatarsal bone; 37, extensor pedis tendon; 38, terminal knob of small metatarsal bone.

femoro-tibial articulation, below the ischio-tibial muscles, constitutes two thick fleshy fasciculi distinct from one another only at their superior extremity, being confounded for the remainder of their extent, and continued inferiorly by a single tendon which extends to the point of the os calcis.

Form—Structure.—Both of these muscular masses are flattened on both sides, thick in the middle, narrow at the extremities, and intersected by strong tendinous bands. By their union they form a wide channel, open in front, which embraces the femoro-tibial articulation and the muscles of the deep layer.

The tendon, at first fasciculated, then single and funicular, receives that of the soleus, and is reinforced by a fasciculus from the fibrous band annexed in front to the tendon of the perforatus (see the *description of the tibial aponeurosis*, p. 362). An aponeurotic layer which covers the gastrocnemius, is continued downwards, partly with the fibrous band, and partly with the tendon of the muscle itself.

Attachments.—The external gemellus arises on the femur, from the rugged lip which margins the supra-condyloid fossa in front; the internal, from the collection of tubercles which constitutes the crest of the same name. The terminal tendon of the two bellies is fixed on the summit of the os calcis, not at its anterior part, but posteriorly; this being lubricated by a bursa that forms a gliding surface on which the tendon rests during extreme flexion of the foot (Fig. 101, 1).

Relations.—By their superficial face, to the three ischio-tibial muscles, and the tibial aponeurosis; by their deep face, to the perforatus—which adheres intimately to the vastus externus—to the posterior ligament of the femoro-tibial articulation, the popliteal muscle and vessels, the great sciatic nerve, and the oblique and deep flexor muscles of the phalanges. The tendon lies beside that of the perforatus, which is twisted around and completely envelops it at its inferior extremity, in common with the fibrous band from the tibial aponeurosis. The two tendons form what is usually termed the *tendon of the hock*, or *tendo Achilles*.

Action.—The gastrocnemius extends the foot upon the tibia. It acts as a lever of the first order when the limb is raised from the ground, and as one of the second order when the hoof is placed on the ground. It maintains the tibio-tarsal angle while the animal is standing, and in progression gives to the hock that spring which carries the body forward.

2. Soleus (Plantaris) (Fig. 201, 21).

Synonyms.—Bourgelat and his successors have erroneously assimilated it to the plantaris of Man. In regarding this little muscle as the soleus, we conform to the well-founded opinion of Cuvier. It is the peroneo-calcaneus of Girard.

Form—Situation.—This is a thin, long, and riband-shaped rudimentary muscle, situated at the external side of the leg, between the tibial aponeurosis and the muscular portion of the perforans.

Attachments.—It is fixed, by its superior extremity, behind the supero-external tuberosity of the tibia; and terminates, inferiorly, by a small tendon, which joins that of the gastrocnemius.

Action.—It is a feeble auxiliary of the last-named muscle.

3. Superficial Flexor of the Phalanges (Flexor Perforatus, Gastrocnemius Internus) (Figs. 201, 25 ; 203, 30).

Synonyms.—Femoro-phalangeus—*Girard.* It is represented in Man by the plantaris and flexor brevis digitorum, or perforatus. These two, in the majority of Mammalia, are united from end to end to form a single muscle.

Form—Structure.—The perforatus of the posterior limb is only represented, in reality, by a long tendinous cord that is somewhat muscular, slightly thickened, and fusiform in its upper fifth, which forms the body of the muscle.

Origin—Direction and Relations—Termination.—It originates, by its upper extremity, in the supra-condyloid fossa, descends between the two portions of the gastrocnemius—to the external of which it is intimately related—on the posterior face of the femoro-tibial articulation, and on the three posterior deep tibial muscles. On reaching the inferior extremities of the muscular bellies of the gastrocnemius, it becomes exclusively tendinous, and is directly united to the fibrous band which reinforces the tendon of the hock. It afterwards disengages itself below the gastrocnemius, and is placed at the internal side of its tendon, then on its posterior surface, and in this position gains the summit of the os calcis. There it becomes widened to form a fibrous cap, which is covered by a large vesicular synovial membrane ; it is moulded to the posterior region of this bony eminence, which it completely envelops in order to be fixed on its lateral portions, and is united to the calcanean band from the tibial aponeurosis. From this point the tendon of the perforatus is prolonged behind that of the perforans, to the posterior face of the second phalanx, where it terminates in exactly the same manner as the analogous muscle of the anterior limb.

Action.—It flexes the second phalanx on the first, and this on the metacarpus It also concurs in the extension of the foot. Its principal office, however, is that of a mechanical stay, destined to sustain the equilibrium of the body while the animal is in a standing posture, by preventing the diminution of the angle of the hock and that of the fetlock—the femur being fixed by the contraction of the crural triceps and the gluteal muscles.

Deep Layer.

4. Popliteus (Fig. 203, 21).

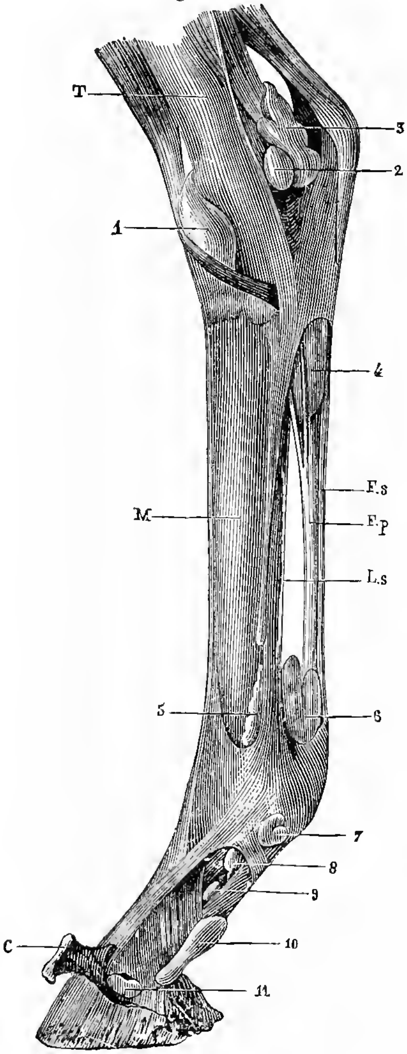
Synonyms.—The abductor tibialis of *Bourgelat*, and femoro-tibialis obliquus of *Girard.*

Situation—Direction—Form—Structure.—Situated behind the tibia, below the femoro-tibial articulation, this muscle is oblique downwards and inwards, short and triangular, tendinous at its supero-external angle, and formed, for the remainder of its extent, of divergent fleshy fibres, the longest of which are the most inferior.

Attachments.—1. In the lowest of the two fossæ on the outside of the external condyle of the femur, by its tendon—*origin.* 2. On the supero-posterior triangular surface of the body of the tibia, by the inferior extremity of its muscular fibres—*termination.*

Relations.—Posteriorly, with the gastrocnemius and perforatus. In front, with the posterior ligament of the femoro-tibial articulation, and the popliteal vessels. Outwards, with the oblique and deep flexors of the phalanges. Inwards, with the semitendinosus and tibial aponeurosis. The tendon, concealed at its origin beneath the external femoro-tibial ligament, glides, by its deep face, over the contour of the external semilunar cartilage and the posterior portion of the external facet on the tibia.

Fig. 204.



ARTICULAR CAPSULES AND BURSÆ IN THE POSTERIOR LIMB OF THE HORSE.

1, Tibio-tarsal capsule (bulging anteriorly); 2, *ibid.* (bulging posteriorly); 3, superior *cul-de-sac* of the tarsal bursa; 4, inferior *cul-de-sac* of the same; 5, capsule of the metatarso phalangeal articulation; 6, 7, 8, superior, middle, and inferior *culs-de-sac* of the sesamoid bursa; 9, posterior *cul-de-sac* of capsule of the first interphalangeal articulation; 10, inferior part of the sesamoid bursa completely exposed by excision of the reinforcing membrane of the perforans tendon; 11, lateral *cul-de-sac* of the second interphalangeal or pedal articulation. T, Tibia; M, matatarsus; C, lateral cartilage turned outwards and forwards; Fs, perforatus tendon; Fp, perforans tendon; Ls, suspensory or superior sesamoid ligament.

Action.—It flexes the tibia, and gives it a slight rotatory movement outwards.

5. Deep Flexor of the Phalanges (Flexor Perforans, Flexor Pedis) (Figs. 201, 23; 203, 23).

Synonyms. — Tibio-phalangeus — *Girard.* The flexor perforans and flexor longus pollicis pedis of Man. (*Great tibio-phalangeus—Leyh.*)

Extent—Situation—Direction—Composition.—Extending from the superior extremity of the leg to the third phalanx, and situated behind the tibia and foot, the direction of which it follows, this muscle is composed of a muscular body and a tendon.

Form, Structure, and Attachments of the muscular portion.—This is thick and prismatic, and incompletely divided into two portions—an internal,[1] and an external,[2] which is the most voluminous. It is attached: 1. To the posterior face of the tibia, on the linear imprints which occupy the inferior triangular surface. 2. To the supero-external tuberosity of the same bone. 3. To the peroneus. 4. To the interosseous ligament uniting that bone to the tibia.

Direction and Attachments of the tendon.—The tendon commences above the inferior extremity of the tibia, where it is usually double, each muscular portion being succeeded by a tendon, the volume of which is in harmony with the size of the muscle from which it proceeds. The single tendon resulting from the union of these two primary ones, enters the groove formed by the inner face of the os calcis, where it is retained by a fibrous arch which transforms this channel into a perfect

[1] The tibialis posticus of Man. [2] The flexor longus pollicis of Man.

sheath, named the *tarsal sheath.* It glides in the interior of this canal by means of a very extensive bursa, which extends upwards on the posterior ligament of the tibio-tarsal articulation, and is prolonged inferiorly to the middle third of the metatarsus. The tendon of the perforans afterwards descends, vertically, behind the suspensory ligament, receiving from it a strong fibrous band (the *subtarsal ligament*), analogous to that of the fore limb, but less voluminous ; it then passes through the annular portion of the perforatus, is inflected with that muscle over the sesamoid groove, glides on the posterior articulating surface of the second phalanx and that on the navicular bone, thinning out into a *plantar aponeurosis*, which is provided with a phalangeal reinforcing sheath, and finally terminates on the semilunar crest of the os pedis. This tendon, therefore, on leaving the tarsus, comports itself exactly like that of the anterior limb.

Relations.—Outwards, with the lateral extensor of the phalanges, the soleus, and the tibial aponeurosis. Inwards, with this aponeurosis and the oblique flexor. Behind, with the gastrocnemius, the perforatus, and the fibrous band of the tendon of the hock. In front, with the tibia.

The tendon glides in the tarsal sheath by means of a very extensive bursa that ascends on the posterior ligament of the tibio-tarsal articulation, behind which it appears as a soft tumour (*thoroughpin*) when it is distended by synovia (Fig. 204, 3). The bursa descends to about the lower third of the metatarsal region.

Action.—This muscle flexes the phalanges on one another and on the metatarsus. It may also extend the foot in pressing, during its contraction, behind the tibio-tarsal articulation. In addition to this, its tendon acts, while the animal is standing, as a mechanical support to the phalanges and the articular angle of the fetlock.

In the **Ass** and **Mule**, the tendon of the perforans does not receive any subtarsal ligament, this being absent in them.

6. Oblique Flexor of the Phalanges (Flexor Accessorius) (Fig. 203, 22)

Synonyms.—Peroneo-phalangeus—*Girard.* The tibialis posticus of Man. (*Small tibio-phalangeus—Leyh.*)

Situation—Direction—A muscle situated behind the tibia, between the popliteus and the perforans, in a direction slightly oblique downwards and inwards.

Form—Structure.—It is composed of a fleshy fusiform body, intersected by numerous fibrous bands, and provided with a funicular tendon inferiorly

Attachments.—The superior extremity arises behind the external tuberosity of the tibia—*origin.* The tendon is united, by its inferior extremity, to that of the perforans towards the upper third of the metatarsal region—*termination.*

Relations.—The muscular portion responds : in front, to the perforans, the popliteus, and the posterior tibial artery ; behind, to the gastrocnemius and the perforatus. The tendon, at first lodged in a muscular channel in the perforans and covered by the tibial aponeurosis, afterwards enters a tortuous sheath at the inner side of the tarsus, and which is formed by the groove that inclines behind the infero-internal tuberosity of the tibia.

Action.—It is a congener of the deep flexor.

Differential Characters in the Muscles of the Leg in the other Animals.

1. Anterior Tibial Region.

A. **Ruminants.**—Among these animals, the *Ox* presents:

1. A complex muscle, which is represented in the Horse by the anterior extensor of the phalanges, and the tendon of the flexor metatarsi. Single at its superior extremity, which begins by a tendon arising from the digital fossa situated between the trochlea and the external condyle of the femur (Fig. 205, 1), this muscle comprises in its middle part three fleshy divisions, which are terminated inferiorly by tendons.

One of these divisions, situated in front of, and within the other two, has its tendon prolonged to the extremity of the principal metatarsal bone, and is also inserted into the cuneiform bones. It is a flexor of the metatarsal region, and replaces the tendon which performs this function in Solipeds (Fig. 205, 2).

The second, placed external to the preceding, constitutes a *common extensor of the digits*, the tendon of which comports itself exactly like that of the anterior limb (Fig. 205, 5, 5′, 6).

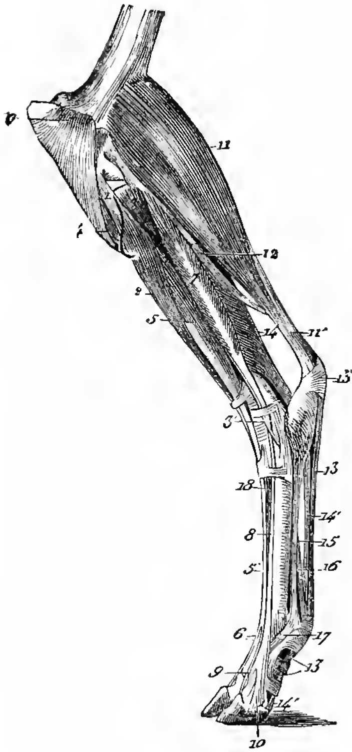
The third, concealed by the other two, forms the *proper extensor of the internal digit*, and resembles its fellow in the fore extremity.

2. An *anterior tibial* muscle (muscular portion of the flexor metatarsi of the Horse). It is a triangular, muscular body, lodged in the antero-external fossa of the tibia, into the upper part of which it is inserted, and is succeeded by a tendon that commences towards the middle of the tibia. This tendon passes through a ring pierced in the tendon of the muscle that represents the tendinous portion of the flexor metatarsi; it then deviates inwards, and is fixed into the cuneiform bones and superior extremity of the principal metatarsal bone (Fig. 205, 4).

3. A *proper extensor of the external digit* (lateral extensor of the phalanges in Solipeds, the peroneus brevis lateralis in Man), the fleshy body of which is altogether similar to that of the analogous muscle in the Horse, and is terminated by a long tendon which resembles that of the proper extensor of the internal digit (Fig. 205, 7, 8, 9, 10).

4. A muscle which represents the *peroneous longus* in Man, and of which in Solipeds there is not a trace. This muscle commences by a short, conical, muscular body in front of the supero-external tuberosity of the tibia, and terminates by a long tendon, the direction of which is as follows: included at first, like the muscular portion, between the proper extensor of the external digit and the triple muscular fasciculus already described, it arrives on the outside of the tarsus, passes through the fibrous groove of the proper extensor, where it is enveloped by a special synovial membrane, passes over the latter in slightly crossing its direction, and is inflected at first backwards, then outwards, by insinuating itself underneath the external tibio-tarsal ligament, and the calcaneo-metatarsal and the posterior tarso-metatarsal ligaments, which retain it in a channel on the inferior face of

Fig. 205.



EXTERNAL MUSCLES OF THE LEG OF THE OX.

1, Originating tendon of the muscle which represents the anterior extensor of the phalanges and the flexor metatarsi in the horse; 2, its flexor fasciculus; 5, that which forms the common extensor of the digits; 5′, the tendon of this fasciculus; 6, its terminal bifurcation; 3, the long lateral peroneus; 3′, its tendon; 4, origin of the anterior tibial (the muscular portion of the flexor metatarsi in the horse); 7, proper extensor of the external digit (short lateral peroneus); 8, its tendon; 9, its insertion into the second phalanx; 10, its insertion into the third phalanx; 11, external belly of the gastrocnemius; 11′, its tendon; 12, soleus; 13, tendon of the perforatus; 14, perforans; 14′, its tendon; 15, suspensory ligament of the fetlock; 16, the band it gives off to the perforatus tendon; 17, that which it sends to the proper extensor of the external digit; 18, the pedal muscle; 19, the insertion of the biceps femoris on the patella, and its external ligament.

the cuboido-scaphoid bone. It is finally inserted into the deep face of the second cuneiform bone, and the external side of the superior extremity of the metatarsus, by a small branch detached from the outer side of the principal tendon.

All these muscles are similarly disposed in the *Sheep* and *Goat.*

B. **Pig.**—The anterior tibial muscles of this animal resemble those of Ruminants, with the exception of some peculiarities of secondary importance, among which the following may be cited:

The muscular fasciculus which replaces the *flexor metatarsi* in the Horse, terminates on the scaphoid and the second cuneiform bone. The *common extensor of the digits* has four tendons—one for each digit. The *proper extensors* have two each—one for the small digit, and the other for the great. The *anterior tibial* passes to the second cuneiform bone. The *peroneus longus lateralis* is inserted, by its tendon, into the upper extremity of the internal metatarsus.

C. **Carnivora.**—Four muscles are described in these animals: 1. An anterior tibial. 2. A long common extensor of the digits. 3. A long lateral peroneus. 4. A short lateral peroneus.

1. *Anterior tibial.*—Situated in front of the tibia, and more voluminous than the common extensor of the digits, the superior extremity of which it covers, this muscle has its origin on the crest and external tuberosity of the tibia. It receives, near the inferior third of this bone, an extremely thin muscular band which proceeds from the fibula, and which we may with justice compare to the *proper extensor of the big toe* in Man. Then it terminates by a tendon on the metatarsal bone of the internal digit; when this bone is connected with a digital region, the third phalanx receives a particular branch from this tendon, which represents the tendinous portion of the small proper extensor fasciculus annexed to the anterior tibial. This muscle responds: in front, to the tibial aponeurosis; inwards and backwards, to the tibia; outwards, to the common extensor of the digits. Its tendon is fixed in the bend of the hock by a fibrous band, the arrangement of which is singular enough to deserve mention here. Attached in front of the inferior extremity of the tibia, this band gives origin, by its internal extremity, to a strong ligament which passes under the tendon of the anterior tibial muscle to reach the anterior face of the tarsus, where it unites closely with the capsular ligament of this region, and terminates on the superior extremity of the metatarsal bone of the middle digit. This ligament binds the inferior extremity of the tibia to the metatarsus, and prevents undue extension of the tibio-tarsal articulation. It is, perhaps, the representative of the tendon of the anterior tibial region in the Horse.

2. *Long common extensor of the digits.*—This muscle is composed of a fusiform fleshy body, and a quadrifurcated tendon. The fleshy body, situated beneath the tibial aponeurosis, between the anterior tibial and the lateral peroneal muscles, covers the external face of the tibia and the small fasciculus of the proper extensor of the thumb; it originates by a short and strong tendon, from the inferior extremity of the femur, between the external condyle and the trochlea. The tendon is continuous with the inferior extremity of the fleshy portion, passes beneath the band of the anterior tibial, through another fibrous ring at the cuboid bone, and is inserted, by its four terminal branches, into the four large digits, in the same manner as the analogous tendon in the fore limb.

3. *Long lateral peroneus.*—This muscle is composed of a very short, conical, fleshy portion, succeeded by a long tendon. The former originates in front of the tuberosity of the supero-external tuberosity of the tibia, and does not appear to have any connection with the fibula. Included between the common extensor of the digits and the short lateral peroneus, it is covered by the tibial aponeurosis, and covers the anterior tibial vessels. The tendon descends parallel with the fibula to its inferior extremity, over which it glides in becoming inflected. On reaching the cuboides, it enters a groove excavated on its external surface, gives off a short isolated branch to the superior extremity of the first metatarsal bone, afterwards crosses transversely the direction of the tarsus in passing behind the inferior row of bones, and terminates on the metatarsus of the thumb. On its way, behind the cuboides, this tendon gives off another branch, which we have every reason to believe is constantly present; it is a short, interosseous fasciculus, that at first penetrates between the cuboides and the external metatarsal bone, then between the latter and the second metatarsal.

This muscle carries the inferior extremity of the limb outwards, and when the foot is much extended it may act as a flexor.

4. *Short lateral peroneus.*—In Carnivora, this muscle is formed by two fasciculi—a superior and inferior, which may be described as two distinct muscles.

The superior fasciculus is a very weak muscular portion, attached to the upper third of the anterior border of the fibula, and a funicular tendon succeeding its inferior extremity about the middle of the tibia. This tendon glides over the inferior extremity of the fibula, behind the long lateral peroneus, which it passes under and crosses, in descending to the phalanges of the external digit, where it is united to the tendinous branch of the common extensor belonging to this digit.

The inferior fasciculus has its origin on the anterior border and external aspect of the peroneus, by penniform fibres, which join a short, but more voluminous tendon than that of the preceding fasciculus. This tendon, with the last, enters the posterior groove in the fibula, and is attached, by its inferior extremity, to the upper end of the external metatarsus, outside the branch furnished by the long lateral peroneus to that bone.

The superior fasciculus acts as a proper extensor of the external digit. The inferior is an abductor of the foot.

2. Posterior Tibial Region.

A. **Ruminants.**—In the *Ox*, *Sheep*, and *Goat*, the muscular portion of the *perforatus* is thicker than in Solipeds. The portion of the *perforans* which represents the tibialis posticus is also better defined than in them; it is lodged in a depression on the principal portion, and can easily be traced from the supero-external surface of the tibia, where it originates. The tendon does not differ from that in the fore limb; but the bands which descend from the metatarsus to the heels, to be united with the two terminal branches of this tendon, are much smaller than those in the metacarpal region.

In the *Camel*, the *popliteus* is altogether confined to the upper and posterior part of the tibia. The *perforatus* is almost exclusively tendinous; in its deeper portion there is a slight expansion in which there are a few muscular fibres. The *perforans* has a very small fusiform muscle; its tendon glides on the internal face of the os calcis, in a slight depression representing the tarsal bursa; it unites with the oblique flexor, and comports itself as in the anterior limb. The *oblique flexor of the phalanges* is remarkable for its volume; instead of being an accessory to the deep flexor, as in the other species, it alone forms the principal head of the perforans tendon, the essential fleshy body of which is found, on the contrary, to be represented in the majority of the other animals, by the analogue of the long flexor of the great toe.

B. **Carnivora.**—The *soleus* is absent in the *Dog*, but it is found in the *Cat*. The muscular body of the *perforatus* is prismatic, voluminous, and entirely blended—in its upper two-thirds at least—with the external head of the gastrocnemius; these two muscles have therefore a common origin. The tendon is quadrifurcated, as in the anterior limb; it offers on its surface, shortly before its division, several thin muscular bands, traces of the fleshy portion of the common short muscle of the toes in Man. Several of these bands come from the perforans tendon, and all pass to the four terminal branches of the muscle. The terminal tendon of the *perforans* is divided into four or five branches, one for each digit.

The *posterior tibial* is not united, inferiorly, to this tendon, but constitutes a perfectly distinct muscle situated between the deep and oblique flexors of the phalanges. Formed by a very small fleshy body and a long thin tendon, it arises above the peroneus, from the posterior surface of the tibia. Its tendon lies beside that of the oblique flexor, and with it enters the groove behind, and within the inferior extremity of, the tibia. Enveloped by a synovial membrane proper to its passage through this groove, this tendon soon leaves it to pass to the free surface of the posterior tarso-metatarsal ligament, with which it is blended towards the middle of the tarsus.

Comparison of the Muscles of the Leg of Man with those of Animals.

In Man, the muscles of the leg are divided into three regions: an anterior, external, and posterior.

I. Anterior Region (Fig. 203).

This includes three muscles:

1. The *anterior tibial*, which corresponds to the fleshy portion of the flexor of the metatarsus, and the imperforate tendon of which is fixed into the first cuneiform.

2. The *common long extensor of the toes*, which represents the anterior extensor of the phalanges of the Horse. This muscle is attached, above, to the external tuberosity of the tibia and the upper three-fourths of the inner face of the fibula: its tendon divides into two fasciculi, the internal of which furnishes a branch to the second, third, and fourth toes, and the external goes to the fifth.

3. The *proper extensor of the great toe*, represented in the Dog by a small fasciculus blended with the anterior tibial, is an elongated semi-penniform muscle that arises from the inner face of the fibula and the interosseous ligament, and terminates on the second phalanx of the great toe, after receiving the *pedal* tendon (*extensor brevis digitorum*).

2. External Region (Fig. 206).

This region is only composed of two muscles: the *long* and *short peroneus.*

The first, which does not exist in Solipeds, is a penniform muscle attached to the upper third of the fibula, the external tuberosity of the tibia, and the internal face of the tibial aponeurosis, by the superior extremities of its muscular fibres. The flat tendon which terminates it is fixed to the outer portion of the base of the first metatarsal.

The second corresponds to the lateral extensor of the phalanges of the Horse, and is found in all animals. It is penniform, and is attached above, by its fleshy fibres, to the lower two-thirds of the external face of the fibula; below, by its tendon, to the upper extremity of the fifth metatarsal.

Fig. 206.

MUSCLES OF THE HUMAN LEG (ANTERIOR TIBIAL REGION).

1, Quadriceps extensor inserted into the patella (the figure is on the tendon of the rectus, the vastus internus and externus being on each side); 2, subcutaneous surface of the tibia; 3, tibialis anticus; 4, extensor longus digitorum; 5, extensor proprius pollicis; 6, peroneus tertius; 7, peroneus longus; 8, peroneus brevis; 9, 9, borders of the soleus muscle; 10, part of the inner belly of the gastrocnemius; 11, extensor brevis digitorum (the tendon in front of the cipher is that of the peroneus tertius; that behind it, the peroneus brevis).

Fig. 207.

SUPERFICIAL POSTERIOR MUSCLES OF THE HUMAN LEG.

1, Biceps forming outer ham-string; 2, tendons forming inner ham-string; 3, popliteal space; 4, gastrocnemius; 5, 5, soleus; 6, tendo-Achilles; 7, posterior tuberosity of os calcis; 8, tendons of peroneus longus and brevis passing behind the outer ankle; 9, tendons of tibialis posticus and flexor longus digitorum passing into the foot behind the inner ankle.

These two muscles determine very complicated movements in the region of the foot.

3. Posterior Region (Fig. 207).

The posterior tibial muscles form two layers: a superficial and a deep.

The first comprises the *crural triceps* and the *plantaris*. The triceps itself is composed of the *gastrocnemius*, of which we will say nothing, and the *soleus*. The latter is flattened from before to behind, attached to the upper third of the fibula, the oblique line of the tibia, and the middle third of the inner border of this bone, and terminated by an aponeurotic lamina which is blended with the tendo-Achilles. The *plantaris* is formed by a small fusiform muscular body, situated beneath the external gemellus, then by a long slender tendon, which is confounded with the inner border of the tendo-Achilles, or is inserted into the os calcis.

The deep layer is composed of four muscles:

1. The *popliteus*, which in its attachments and position resembles that of animals.

2. The *common long flexor of the toes*, corresponding to the oblique flexor of animals. It is an elongated penniform muscle, fixed above to the oblique line and middle third of the posterior face of the tibia. Its tendon is inflected beneath the external malleolus, passes in front below the astragalus, receives the accessory of the long flexor, and then divides into four branches for the four lesser toes.

3. The *posterior tibial*, represented by a portion of the perforans of animals; its tendon is reflected beneath the internal malleolus of the tibia, and is attached to the scaphoid process.

4. The *proper long flexor of the great toe*, also represented by a portion of the perforans. This muscle is voluminous and prismatic, and is attached above to the lower two-thirds of the posterior face of the fibula. Its tendon is reflected inwards on the astragalus and the groove in the os calcis, crosses the tendon of the common long flexor, and terminates on the posterior extremity of the third phalanx of the great toe.

Muscles of the Posterior Foot.

In Solipeds are found: 1. *Two lumbrici* and *two interosseous* muscles, corresponding to those of the anterior limb. 2. A *pedal* muscle.

Pedal Muscle (Extensor Pedis Brevis, Extensor Brevis Digitorum).

Synonym.—The *tarso-prephalangeus* of Girard.

This is a small riband-shaped fasciculus, situated in front of the principal metatarsal bone, beneath the extensors of the phalanges. It is attached, by its inferior extremity, to the internal surface of the tendon common to these two muscles, and by its upper extremity to the lower end of the os calcis (and astragalus). It aids in extending the digit (flexing the hock, and probably keeping the tendons tense.)

Differential Characters in the Muscles of the Posterior Foot in the other Animals.

A. **Ruminants.**—This is the only muscle in the region of the foot met with in Ruminants. It is attached, inferiorly, to the tendon of the common extensor and that of the proper extensor of the internal digit.

B. **Pig.**—This animal possesses: 1. A *pedal* muscle attached, below, to the two branches of the common extensor of the large digits. 2. Four *interosseous metatarsal muscles*, which do not appear to differ in their general arrangement from the metacarpal interosseous muscles.

C. **Carnivora.**—In the *Dog* and *Cat* there exist in the region of the posterior foot:

1. A *pedal* muscle, composed of three fasciculi which have their origin either from the inferior extremity of the os calcis, or from the tendinous sheaths in the bend of the hock; they terminate on the second, third, and fourth digits, by small tendons joined to the branches of the common extensor.

2. The muscular digitations annexed to the tendon of the perforatus, traces of the fleshy portion of the *flexor brevis digitorum* of Man.

3. A *flexor pedis accessorius*, or *perforans*, a small undeveloped muscle commencing outside the tarsus, and terminating by a very delicate aponeurosis on the posterior face of the perforans tendon.

4. Two or three pale and rudimentary bands, situated inside the tarsus and near the internal digit. These are the vestiges of the *muscles proper to the great toe* in Man.

5. An *adductor of the little toe* (abductor minimi digit) is a thin, elongated muscle, carried obliquely from the posterior tarso-metatarsal ligament to the internal side of the first phalanx of that digit.

6. Four *interosseous metatarsal* muscles, resembling the analogous muscles of the metacarpal region.

7. *Lumbrici* similar to those of the anterior limb.

Comparison of the Muscles of the Foot in Man with those of Animals.

In *Man*, there are distinguished the muscles of the dorsal region, the plantar region, and the interosseus muscles.

1. Dorsal Region.

This only contains one muscle, the *pedal* (*extensor brevis digitorum*). It is attached, behind, to the antero-external part of the upper face of the os calcis, by several aponeurotic layers; its fleshy fasciculi, four in number, are prolonged by as many tendons destined to the first four toes; three of them pass along with the tendons of the common extensor.

2. Plantar Region.

This is subdivided into three regions: a middle, internal, and external.

The first comprises: 1. The *common short flexor of the toes*, which is represented in Soli-

Fig. 208.

FIRST LAYER OF PLANTAR MUSCLES OF HUMAN FOOT.

1, Os calcis; 2, posterior part of plantar fascia divided transversely; 3, abductor pollicis; 4, abductor minimi digitii; 5, flexor brevis digitorum; 6, tendon of flexor longus pollicis; 7, 7, lumbricales.

Fig. 209.

THIRD AND PART OF SECOND LAYER OF PLANTAR MUSCLES OF HUMAN FOOT.

1, Incised plantar fascia; 2, musculus accessorius; 3, tendon of flexor longus digitorum; tendon of flexor longus pollicis; 5, flexor brevis pollicis; 6, adductor pollicis; 7, flexor brevis minimi digitii; 8, transversus pedis; 9, interossei muscles, plantar and dorsal; 10, convex ridge formed by the tendon of the peroneus longus in its oblique course across the foot.

peds by a portion of the perforatus. It is attached to the infero-internal tuberosity of the os calcis, and to the upper face of the middle plantar aponeurosis. It has four tendons, which are inserted into the second phalanges of the first four toes, after forming rings through which pass the tendons of the common long flexor.

2. The *accessory of the long flexor*, the fibres of which pass to the tendons of the common flexor.

3. The *lumbrici*, four in number, and analogous to those of the hand.

The internal plantar region is composed of three muscles, which are found in a rudimentary condition in the Dog.

1. The *short adductor of the great toe*, which extends from the internal tuberosity of the os calcis to the internal sesamoid and the first phalanx of the great toe.

2. The *short flexor of the great toe*, which arises from the third cuneiform and the tendon of the posterior tibial, and terminates by two branches on the external sesamoid and the internal sesamoid of the great toe.

3. The *short adductor of the great toe*, a muscle formed by two fasciculi, and having a common termination on the external sesamoid. One of these fasciculi arises from the inferior face of the cuboides, the third cuneiform, and the base of the third and fourth metatarsal; it has been formerly described as the *oblique adductor*. The other has its origin from the inferior face of the three last metatarso-phalangeal articulations: this has also been called the *transverse adductor*.

The external plantar region likewise comprises three muscles, which are—

1. The *short abductor of the little toe*, which is detached from the internal tuberosity of the os calcis, and is inserted into the external portion of the first phalanx of the little toe.

2. The *short flexor of the little toe* is attached, behind, to the sheath of the long peroneus and to the process of the fifth metatarsal; in front, to the external part of the first phalanx of the little toe.

3. The *opponens of the little toe*, concealed beneath the preceding, is inserted at one end to the sheath of the long peroneus, and at the other to the external border of the fifth metatarsal.

3. Interosseous Muscles.

These are divided into *dorsal* and *plantar interossei*. Their disposition is nearly the same as in the hand.

CHAPTER III.

THE MUSCLES IN BIRDS.

In Birds, we find the majority of the muscles already described; though they are appropriate by their form, volume, arrangement, etc., to the particular conformation of the skeleton in these animals.

To undertake, in this essentially practical work, a special description of all these muscles, would be to depart from the object aimed at; and we therefore confine ourselves to those points which present most interest, so far as animal mechanics is concerned.

1. *Tendons.*—The tendons in birds present in the inferior limbs and at the extremity of the wings an amount of ossification more or less extensive along their course. This transformation of the fibrous tissue of the muscles is not the effect of senility, for it is noticed in very young animals.

The tendons, in losing the greater part of their elasticity, doubtless gain in tenacity; and this allows them to transmit to the bony levers the muscular efforts in a more integral manner.

It is also observed that the partial ossification of the tendons does not exclusively belong to the limbs; for it is not rare to meet with this change in other regions, as in the neck of wading birds. In the museum of the Veterinary School at Lyons is the skeleton of a heron which shows this peculiarity in the highest degree; the cervical vertebræ are roughened by a multitude of filiform bony stylets, all directed backwards, and which have originated from the ossification of the tendinous fibrillæ annexed to the muscles of the cervical region.

2. *The Pectoral Muscles.*—The two alternative movements which produce flight—the elevation and depression of the wings—being due to the action of the pectoral muscles, these merit special notice.

The *superficial* or *great pectoral*, "which alone weighs heavier than all the other muscles of the bird put together, is attached to the furculum, to the great ridge of the sternum, and to the last ribs ; it is inserted into the very salient rugged outline of the humerus. It is by this muscle that birds are able to give those powerful strokes of the wings which are necessary in flight."

The *deep* or *small pectoral* is "placed in the angle formed by the body of the sternum and its crest, and in the interval between the furculum and the coracoid bone. Its tendon passes through the foramen formed by the union of the furculum, the coracoid bone, and the scapula, as over a pulley ; it is inserted above the head of the humerus, which it raises. It is by means of this arrangement that nature has been able to place an elevator and depressor at the inferior surface of the trunk so far from the centre of gravity, without which the bird would have been liable to lose its equilibrium and tumble over head foremost in the air." [1]

Cuvier, adopting the nomenclature of Vicq-d'Azyr, called this muscle the *middle pectoral*, and he gave the name of *small pectoral* to a triangular fasciculus which leaves the lateral angle of the sternum and the base of the coracoid bone, to be inserted under the head of the humerus. In our opinion, this tendon does not belong to the pectoral region, but to that of the shoulder ; and, with J. F. Meckel, we are inclined to consider it as the curaco-humeralis, which has followed the coracoid process in its development.[2]

3. *The Diaphragm.*—"In Birds, the diaphragm is so differently disposed from what it is in the higher Vertebrata, that its existence has been successively described and misunderstood, admitted and refuted, and is still looked upon as problematical by a large number of anatomists. Nevertheless, this muscle exists, and its development is in perfect harmony with the importance of its functions. It is composed of two planes, which at their origin are confounded with each other, but soon become separated and pursue, one a transverse, the other an oblique direction. The transverse plane is triangular in form, and is carried horizontally from the right to the left ribs against the inferior surface of the lungs. The oblique plane is convex in front, concave behind, and extends from the dorsal aspect of the spine to the sternum, dividing the cavity of the trunk into two secondary cavities—the thorax and abdomen.

"In Birds, as in Mammals, the diaphragm is therefore intended to perform two principal functions ; but to do this perfectly in the former, it is doubled. So far, then, from this inspiratory muscle being absent in birds, or from its existing in a rudimentary degree, they are really provided with two diaphragms : 1. A *pulmonary diaphragm*, which presides in the dilatation of the lungs. 2. A *thoracic abdominal diaphragm*, which partitions the great cavity of the trunk, and concurs in the inspiration of the air by dilating the large aërial reservoirs lying at its posterior surface. Of these two muscular planes, the first is analogous to that portion of the diaphragm which, in Man and the Mammalia, is inserted

[1] Cuvier, *Leçons d'Anatomie Comparée.*

[2] E. Geoffroy Saint-Hilaire, in his memoir on the bones of the sternum (*Philosophie Anatomique*, vol. i. p. 89), in comparing the pectoral muscles of Fishes to those of Birds, also employs the nomenclature of Vicq-d'Azyr, and recognizes three pectorals as well. We are, however, obliged to confess ourselves as in opposition to the great master who has established rules to follow in the classification of organs, in consequence of his having limited his comparisons to the two classes of Vertebrata he had principally in view. If he had extended his observations to the Mammalia, and in them sought for the analogue of the *pectoralis parvus*, he would have discovered it, as we have done, in the region of the shoulder, and not in that of the sternum.

into the sternum and the ribs ; the second manifestly represents the pillars of the diaphragm."

This description, taken from the work of Sappey, an observer as conscientious as he is talented, gives a perfectly exact idea of this muscle.

CHAPTER IV.

GENERAL TABLE OF THE ATTACHMENT OF THE MUSCLES IN SOLIPEDS.

I. Vertebral Column.

A. Cervical Vertebræ.

1. Atlas.

The atlas gives attachment to nine pairs of muscles :—

a. By the surface representing the spinous process, to the—
Rectus capitis posticus minor.

b. By its transverse processes, to the—
1. Splenius.
2. Trachelo-mastoideus.
3. Obliquus capitis anticus.
4. Obliquus capitis posticus.
5. Mastoido-humeralis.

c. By its body, to the—
1. Rectus capitis anticus minor.
2. Rectus capitis lateralis.
3. Longus colli.

2. Axis.

The axis gives insertion to six pairs of muscles :—

a. By its spinous process, to the—
1. Semispinalis colli.
2. Obliquus capitis anticus.
3. Rectus capitis posticus major.

b. By its transverse processes, to the—
1. Intertransversales colli.
2. Mastoido-humeralis muscles.

And by the inferior face of its body, to the—
3. Longus colli.

3. Third, Fourth, Fifth, Sixth, and Seventh Cervical Vertebræ.

These vertebræ give insertion to the following muscles :—

a. By their spinous processes, to the—
1. Semispinalis colli.
2. Longissimus dorsi.

b. By their articular tubercles, to the—
1. Complexus.
2. Trachelo-mastoideus.
3. Semispinalis colli.
4. Intertransversales colli.

c. By their transverse processes, to the—

1. Angularis scapulæ.
2. Splenius (3rd and 4th).
3. Mastoido-humeralis (3rd and 4th).
4. Transversalis costarum.
5. Semispinalis colli.
6. Longissimus colli (inferior branch).

d. And by the inferior faces of their bodies, to the—

1. Rectus capitis anticus major.
2. Longus colli.

B. Dorsal Vertebræ.

The dorsal vertebræ give insertion :—

a. By their spinous processes, to the—

1. Splenius (1st to 5th or 6th).
2. Complexus (1st to 6th).
3. Trachelo-mastoideus (1st and 2nd).
4. Trapezius.
5. Latissimus dorsi (4th to 18th).
6. Rhomboideus (2nd to 7th).
7. Serratus anticus (2nd to 13th).
8. Serratus posticus (10th to 18th).
9. Longissimus dorsi.
10. Semispinalis of the back and loins.

b. By their transverse processes, to the—

1. Complexus.
2. Trachelo-mastoideus.
3. Longissimus dorsi.
4. Semispinalis of the back and loins.
5. Levatores costarum.

c. By their bodies, to the—

1. Longus colli (1st to 6th).
2. Psoas magnus (17th to 18th).
3. Psoas parvus (16th to 18th).

C. Lumbar Vertebræ.

The lumbar vertebræ give insertion :—

a. By their spinous processes, to the—

1. Latissimus dorsi.
2. Serratus posticus (1st to 3rd).
3. Longissimus dorsi.
4. Semispinalis of the back and loins.

b. By their articular tubercles, to the—

1. Longissimus dorsi.
2. Semispinalis of the back and loins.

c. By their transverse processes, to the—

1. Psoas magnus.
2. Quadratus lumborum.
3. Intertransversales of the loins.
4. Transversus abdominis.
5. Longissimus dorsi.

d. By their bodies, to the—

1. Psoas magnus.
2. Psoas parvus.
3. Crura of the diaphragm.

D. Sacrum.

The sacrum gives insertion to the—

1. Longissimus dorsi.
2. Semispinalis of the back and loins.
3. Erector coccygis.
4. Curvator coccygis.
5. Depressor coccygis.
6. Ischio-coccygeal muscles.
7. Biceps femoris.
8. Semitendinosus.
9. Obturator internus.

E. Coccyx.

The coccyx gives insertion to the

1. Erector coccygis.
2. Depressor coccygis.
3. Curvator coccygis.
4. Ischio-coccygeal muscles (1st aud 2nd coccygeal vertebræ).

II. Head.

A. Bones of the Cranium.

1. Occipital.

The occipital gives insertion to nine pairs of muscles :—

1. Complexus.
2. Obliquus capitis posticus.
3. Rectus capitis posticus major.
4. Rectus capitis posticus minor.
5. Rectus capitis anticus major.
6. Rectus capitis anticus minor.
7. Rectus capitis lateralis.
8. Digastricus.
9. Occipito-styloid.

2. Parietal.

The parietal gives attachment to one muscle :—

Temporalis.

3. Frontal.

The frontal gives insertion to the—

Levator labii superioris proprius.

4. Sphenoid.

The sphenoid gives attachment to four muscles :—

1. Rectus capitis anticus major.
2. Rectus capitis anticus minor.
3. Pterygoideus internus.
4. Pterygoideus externus.

5. Temporal.

The temporal gives insertion to five muscles :—

1. Splenius.
2. Trachelo-mastoideus.
3. Obliquus capitis postious.
4. Mastoido-humeralis.
5. Temporalis.

B. Bones of the Face.

1. Superior Maxilla.

The supermaxilla gives insertion to the following muscles :—

1. Panniculus.
2. Buccinator.
3. Levator labii superioris propria.
4. Dilator naris lateralis.
5. Masseter.

2. Premaxilla.

The premaxilla gives insertion to the—

1. Dilator naris superior.
2. Levator menti.

3. Palatine.

The palatine gives insertion to the—

Pterygoidcus internus.

4. Malar.

The malar gives insertion to one muscle, the—

Levator labii superioris proprius.

5. Lachrymal.

The lachrymal gives insertion to one muscle, the—

Lachrymalis.

6. Nasal.

The nasal gives insertion to one muscle, the—

Levator labii superioris proprius.

7. Inferior Maxilla.

The inferior maxilla gives insertion to the following muscles :—

1. Sterno-maxillaris.
2. Buccinator.
3. I epressor labii inferiore
4. Levator menti.
5. Masseter.
6. Temporalis.
7. Pterygoideus internus.
8. Pterygoideus externus.
9. Digastricus.
10. Mylo-hyoideus.
11. Genio-hyoideus.

C. Hyoid.

The hyoid gives insertion to the following muscles :—

a. By its body and its thyroid cornua—

1. Sterno-hyoideus.
2. Subscapulo-hyoideus.
3. Mylo-hyoideus.
4. Genio-hyoideus.
5. Stylo-hyoideus.
6. Hyoideus magnus.
7. Hyoideus transversus.

b. By its branches (styloid cornua and styloid bones)—

1. Stylo-hyoideus.
2. Hyoideus magnus.
3. Occipito-styloideus.

III. Bones of the Thorax.

A. The Ribs and their Cartilages.

The ribs and costal cartilages give attachment to seventeen muscles :—

1. Scalenus (1st).
2. Serratus anticus (5th to 9th).
3. Serratus posticus (9th to 18th).
4. Longissimus dorsi (3rd to 18th).
5. Transversalis costarum.
6. Psoas magnus (17th to 18th).
7. Quadratus lumborum (16th to 18th).
8. Serratus magnus (1st to 8th).
9. External intercostals.
10. Internal intercostals.
11. Levatores costarum.
12. Triangularis sterni (2nd to 8th).
13. Obliquus abdominis externus (5th to 18th).
14. Obliquus abdominis internus (asternal cartilages).
15. Rectus abdominis (asternal cartilages).
16. Transversalis abdominis.
17. Diaphragm (7th to 18th).

B. Sternum.

The sternum gives attachment to nine muscles :—

1. Panniculus cervicalis of the neck.
2. Sterno-maxillaris.
3. Sterno-thyro-hyoideus.
4. Superficial pectorals
5. Deep pectorals.
6. Triangularis sterni.
7. Rectus abdominis.
8. Transversalis abdominis.
9. Diaphragm.

IV. Thoracic Limb.

A. Bones of the Shoulder.

Scapula.

The scapula gives attachment to seventeen muscles :—

a. By its external face, to the—

1. Supra-spinatus.
2. Infra-spinatus.
3. Teres minor.
4. Teres externus.
5. Trapezius.
6. Mastoido-humeralis.

b. By its internal face, to the—

1. Rhomboideus.
2. Angularis scapulæ.
3. Serratus magnus.
4. Subscapularis.
5. Scapulo-humeralis gracilis.

c. By its anterior border, comprised between the cervical angle and the coracoid process, to the—

1. Sterno-prescapularis.
2. Biceps.
3. Coraco-humeralis.
4. Supra-spinatus.

d. By its posterior border, comprised between the dorsal angle and the corresponding portion of the humeral angle, to the—

1. Caput magnum.
2. Scapulo-ulnaris.
3. Teres major.
4. Deltoid.
5. Teres minor.

B. Bones of the Arm.

Humerus.

The humerus gives attachment to twenty-four muscles :—

a. By its superior extremity, to the—

1. Supra-spinatus.
2. Infra-spinatus.
3. Subscapularis.
4. Scapulo-humeralis gracilis.
5. Posterior deep pectoral.
6. Panniculus carnosus.

b. By its body, to the—

1. Deltoid.
2. Teres minor.
3. Coraco-humeralis by two points.
4. Teres major.
5. Brachialis anticus.
6. Caput medium.
7. Caput parvum.
8. Anconeus.
9. Extensor metacarpi magnus.
10. Extensor pedis.

11. Latissimus dorsi.
12. Mastoido-humeralis.
13. Anterior superficial pectoral.

c. By its inferior extremity, to the—

1. Extensor pedis.
2. Flexor metacarpi externus.
3. Flexor metacarpi obliquus.
4. Flexor metacarpi internus.
5. Flexor pedis perforatus.
6. Flexor pedis perforans.

C. Bones of the Forearm.

1. Radius.

The radius gives attachment :—

a. By its upper extremity, to the—

1. Biceps.
2. Extensor pedis.
3. Extensor suffraginis.

b. By its body, to the—

1. Brachialis anticus.
2. Extensor metacarpi obliquus.
3. Extensor pedis.
4. Extensor suffraginis.
5. Flexor pedis perforans.

2. Ulna.

The ulna gives attachment to nine muscles :—

a. By its upper extremity (olecranon), to the—

1. Caput magnus.
2. Scapulo-ulnaris.
3. Caput medium.
4. Caput parvum.
5. Anconeus.
6. Flexor metarcarpi obliquus.
7. Flexor pedis perforans.

b. By its body, to the—

1. Brachialis anticus.
2. Extensor suffraginis.

D. Bones of the Carpus.

Pisiform Bone.

The supercarpal bone, the only bone of the carpus which has muscular attachments, gives attachment to two muscles :—

1. Flexor metacarpi externus.
2. Flexor metacarpi medius.

E. Bones of the Metacarpus.

1. Principal Metacarpal.

The principal metacarpal gives attachment to a single muscle :—

By its superior extremity, to the—

Extensor metacarpi magnus.

2. External Rudimentary Metacarpal.

This gives attachment to a single muscle :—

Flexor metacarpi externus.

3. Internal Rudimentary Metacarpal.

This gives attachment to two muscles :—

1. Extensor metacarpi obliquus.
2. Flexor metacarpi internus.

F. Bones of the Digital Region.

1. First Phalanx.

This gives attachment to two muscles :—

1. Extensor pedis.
2. Extensor suffragiuis.

2. Second Phalanx.

This gives attachment to two muscles :—

1. Extensor pedis.
2. Flexor pedis perforatus.

3. Third Phalanx.

The third phalanx, or os pedis, gives attachment to two muscles :—

1. Extensor pedis.
2. Flexor pedis perforans.

V. Abdominal Limb.

A. Bones of the Haunch.

Coxa.

The coxa gives attachment to thirty-two muscles :—

a. By the ilium, to the—

1. Longissimus dorsi.
2. Iliacus.
3. Psoas parvus.
4. Quadratus lumborum.
5. Compressor coccygis.
6. Obliquus abdominis externus.
7. Obliquus abdominis internus.
8. Transversalis abdominis (through the medium of the crural arch).
9. Gluteals.
10. Teusor vaginæ femoris.
11. Rectus femoris.
12. Rectus parvus.
13. Obturator internus.

b. By the pubis, to the—

1. Obliquus abdominis externus.
2. Rectus abdomiuis.
3. Transversalis abdominis (through the medium of the crural arch).
4. Gracilis.
5. Pectineus.

6. Adductor parvus.
7. Obturator externus.
8. Obturator internus.

c. By the ischium, to the—

1. Superficial gluteus.
2. Biceps femoris.
3. Semitendinosus.
4. Semimembranosus.
5. Gracilis.
6. Adductor magnus.
7. Quadratus femoris.
8. Obturator externus.
9. Obturator internus.
10. Gemelli of the pelvis.

B. Bones of the Thigh.

Femur.

The femur gives attachment to twenty-four muscles :—

a. By its upper extremity, to the—

1. Psoas magnus.
2. Iliacus.
3. Superficial gluteus.
4. Middle gluteus.
5. Deep gluteus.
6. Obturator externus.
7. Obturator internus.
8. Gemelli of the pelvis.

b. By its body, to the—

1. Superficial gluteus.
2. Fascia lata.
3. Vastus externus.
4. Vastus internus.
5. Rectus parvus.
6. Pectineus.
7. Adductor parvus.
8. Adductor magnus.
9. Quadratus femoris.
10. Gastrocnemius.
11. Flexor pedis perforatus.

c. By its inferior extremity, to the—

1. Semimembranosus.
2. Adductor magnus.
3. Extensor pedis.
4. Flexor metatarsi.
5. Popliteus.

C. Bones of the Leg.

1. Tibia.

The tibia gives attachment to eleven muscles :—

a. By its upper extremity, to the—

1. Flexor metatarsi.
2. Soleus.
3. Flexor pedis perforans.

4. Flexor accessorius.
5. Sartorius (through the medium of the internal patellar ligament).

b. By its body, to the—

1. Biceps femoris.
2. Semitendinosus.
3. Gracilis (in common with the long adductor).
4. Flexor metatarsi.
5. Popliteus.
6. Flexor pedis perforans.

2. Fibula.

The fibula gives insertion to two muscles :—

1. Extensor suffraginis.
2. Flexor pedis perforans.

3. Patella.

The patella gives insertion to five muscles :—

1. Tensor vaginæ femoris.
2. Rectus femoris.
3 Vastus externus.
4. Vastus internus.
5. Superficial gluteus (posterior portion).

D. Bones of the Tarsus.

Calcis.

The calcis gives insertion to the—

Gastrocnemius.

Cuboid.

The cuboid gives insertion to the—

Flexor metatarsi.

Second Cuneiform.

This gives attachment to one muscle, the—

Flexor metatarsi.

E. Bones of the Metatarsus.

The principal metatarsal gives insertion to one muscle, the—

Flexor metatarsi.

F. Bones of the Foot.

1. First Phalanx.

The first phalanx gives insertion to one muscle, the—

Anterior extensor of the phalanges.

2. Second Phalanx.

The second phalanx gives insertion to two muscles :—

1. Extensor pedis.
2. Flexor pedis perforatus.

3. Third Phalanx.

The third phalanx gives insertion to two muscles :—

Extensor pedis.
Flexor pedis perforans.

BOOK II.

THE DIGESTIVE APPARATUS.

CHAPTER I.

General Considerations on the Digestive Apparatus.

We have considered the animal as a machine composed of various levers and capable of various movements; but it will be easily understood that the working of this machine will cause the wear or decomposition of the molecules which enter into the construction of its organs, and that these springs or animated wheels demand for their maintenance an incessant supply of new materials, in order to repair their continual losses. Animals, therefore, are under the necessity of taking *aliment*, from which they extract those reparative principles that, distributed to all the organs, are assimilated to their proper substance.

The organs in which this work of preparation and absorption of the organizable material is carried on, are collectively named the *digestive apparatus*—one of the most important of those which, as we shall see, successively complicate and perfect the animal machine. This apparatus does not, properly speaking, constitute an essentially distinctive characteristic of animality, as there are animals without a digestive cavity; but it is yet one of the most salient attributes, for the exceptions just mentioned are extremely rare. Considered in the Vertebrata, this apparatus appears as a long tube, most frequently doubled on itself many times, dilated at intervals, and provided along its course with several supplementary organs, the majority of which are of a glandular nature. This tube extends the whole length of the animal's body, and opens externally by two orifices, one of these serving for the introduction of aliment, the other for the expulsion of the residue of digestion. These openings are at the extremities of the alimentary canal.

The conformation of this apparatus is not incidentally the same in all the individuals composing the sub-kingdom of Vertebrata; on the contrary, it presents very numerous varieties, according to the habits and modes of life of these individuals, and this makes its study interesting from two points of view: in relation to the science of zoology, and to that of veterinary hygiene, which derives from this study valuable indications concerning the *régime* of the domesticated animals.

But this diversity of characters does not suffice to establish sharply defined limits between the conformations that are distinguished by it. There is, in reality, but one typical form of digestive apparatus, and the same principle prevails in its construction throughout the entire series. Thus, whichever of the Vertebrata we may be studying, its alimentary tube will be found composed of a collection of dilatations or tubuliform cavities, which succeed each other from before to behind in the following order: the *mouth*, *pharynx*, *œsophagus*, *stomach*, and *intestine*.

This system of cavities is divided, physiologically, into two principal sections. The first comprises the mouth, pharynx, and œsophagus—the compartments in which are carried on those digestive operations termed *preparatory*, because they prepare the aliment for the subsequent modifications that constitute the essential phenomena of digestion; the second section is formed by the stomach and intestines, where these phenomena take place.

Each of these two sections is furnished in its course with annexed organs, which are present in the majority of Vertebrata; these are the *salivary glands* for the cavities of the first category, and the *liver*, *pancreas*, and *spleen* for those of the second.

In considering the general position of these various parts—principally in Mammals and Birds—it is found that the first section of the digestive canal and its appended organs are lodged beneath the upper jaw and the base of the cranium, and under the cervico-thoracic portion of the vertebral spine. The second section, with its annexes, occupies the great abdominal cavity.

In Man, these two sections are divided into *supra-diaphragmatic* and *infra-diaphragmatic regions*, because of their relations to the diaphragm.

The constituent parts of the first category might be termed, by reason of their functions, the *preparatory organs of the digestive apparatus*; and those of the second, or abdominal portion, the *essential organs of digestion*.

These various organs, with those of the respiratory and genito-urinary apparatus, have received the name of *viscera*, and the term *splanchnology* is often given to that branch of anatomy devoted to their study.[1]

These new organs differ so notably from those already described, that it is necessary to enter into some generalities as to their nomenclature, arrangement, form, structure, and physical or chemical characteristics.

Nomenclature in splanchnology does not rest on any scientific basis; the name of organs being sometimes derived from their form—as the *amygdalæ*; sometimes from their direction—*rectum*; sometimes also from their uses—the *œsophagus*, *salivary glands*; their length—*duodenum*; the names of the anatomists who have described them—the *duct of Steno*, *Fallopian tube*; and at times these names are purely conventional, as the *spleen*.

They are distinguished as *hollow* and *solid organs*.

1. The HOLLOW ORGANS have a more or less considerable cavity, capable of being increased or diminished, but they are not of a definite shape or size. Their consistency varies with their state of plenitude or vacuity, and they are single or double, symmetrical or asymmetrical.

In all cases, the walls of the hollow organs are composed of two or more membranes, which we will now describe in a general manner.

[1] The designation *viscera* (from *vescor*, "I nourish") has been given to the organs which aid in nutrition, and the term *Splanchnology* (from σπλάγχνον, a "viscus" or "intestine") has been bestowed on that division of anatomy which treats of these organs. Splanchnology, thus understood, comprises the study of the digestive, respiratory, urinary, and circulatory apparatus. But the description of the latter forms a separate category, designated, in the language of the schools, *Angiology*. On the other hand, however, several authorities include in Splanchnology the organs of generation, and others even add the organs of sense. There is, therefore, no accord in the limits given to the definition of Splanchnology; and this being the case, we have thought it best to omit this expression and the distinction sought to be established by it.

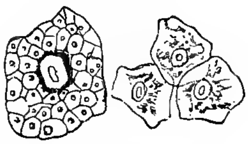
a. The innermost is called the **mucous membrane**, because of the mucus with which its free surface is always covered. It is continuous with the skin at the natural openings; and from its similarity of organization, it has been named the *internal* or *re-entering skin*, or *internal tegumentary membrane.*

It should be remarked, however, that the comparison of the mucous membrane with the skin only holds good at the two ends of the apparatus—anteriorly, from the mouth to the stomach; posteriorly, at the margin of the anus.

A mucous membrane comprises a superficial or *epithelial layer* and a deep portion which constitutes the *dermis*, or *chorion* (*corium*).

The *epithelium* is a very thin, inert pellicle, entirely composed of epithelial cells united by an almost insignificant quantity of amorphous matter (*blastema*). The cells are flat or polygonal, round or cylindrical, polyhedral, or very irregular in shape. In consequence of these diverse forms, there is *pavement* (or *flat*, *simple*, *tesselated*, or *squamous*), *spherical* (or *spheroidal*), and *cylindrical* or *conical* (or *columnar*) *epithelium*. If the cells are furnished with small filiform appendages, named *vibratile cilia*, the epithelium is then designated *ciliated*. When the cells

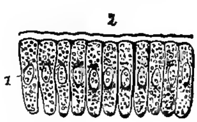
Fig. 210.



SQUAMOUS EPITHELIUM FROM THE MOUTH.

The large scale is magnified 310 diameters, and exhibits a nucleus with nucleolus in the centre, and secondary nucleated cells forming the body of the scale.

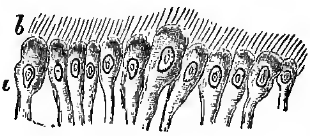
Fig. 211.



COLUMNAR EPITHELIUM.

1, Nucleus of the cell; 2, membrane of the cell raised from its contents by the absorption of water.

Fig. 212.



COLUMNAR CILIATED EPITHELIUM (MAGNIFIED 310 DIAMETERS).

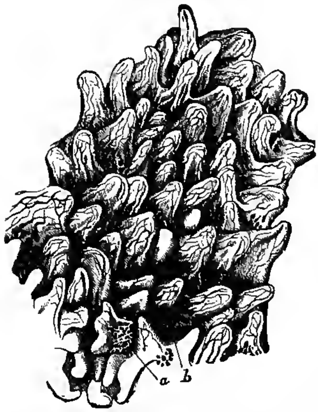
a, Nucleated cells resting on their smaller extremities; *b*, cilia.

are arranged in a single layer on the surface of the corium, the epithelium is said to be *simple*; it is *stratified* (or *laminar*) when the cells are arranged in strata upon each other. In stratified epithelium, the shape of the cells is not the same on the surface and beneath it, and it is named after the form of the superficial layer: examples—*stratified tesselated epithelium*, *stratified cylindrical epithelium*.

The *mucous dermis*, or *corium*, is composed of connective tissue, the thickness, elasticity, vascularity, and sensibility of which varies with the situation and the function of organs. The corium is thin and almost destitute of elastic fibres when applied to the bony walls of a cavity; on the contrary, it is thick, elastic, and slightly adherent when it lines organs which—like the stomach, œsophagus, and intestines—are capable of increasing or diminishing in capacity. The fasciculi of the connective tissue in the deeper layers of the corium are loosely united, but nearer the surface they lie closer; sometimes they form, under the epithelium, an amorphous surface-layer, the *basement* (or *limitary*) membrane. In certain places (intestine), the dermis has a layer of smooth muscular fibres which can be resolved into two planes (the *muscularis mucosæ*).

The sub-epithelial face of the corium is scarcely ever smooth, but offers minute prolongations named *villosities*, or *papillæ*, which are very varied in their form and size; it is more or less marked by depressions, named *follicles*. The villi are observed on the deep-seated mucous membranes (intestine); they are more particularly the vascular and absorbent organs. The *papillæ* are found in the vicinity of the natural apertures, and are rich in nerves; they are more especially the organs of sensibility. The *follicles*, lined by one or other form of cell, are exclusively organs of secretion.

Fig. 213.



CONICAL VILLI ON MUCOUS MEMBRANE OF SMALL INTESTINE (MAGNIFIED 19 DIAMETERS).

a, Zone of follicles surrounding a solitary gland; *b*, apertures of simple follicles.

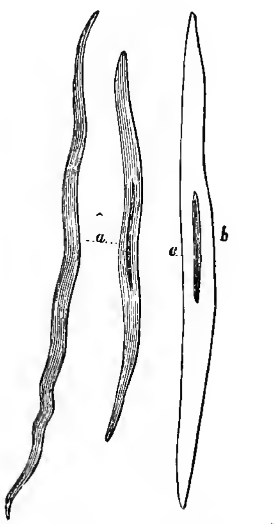
b. The second membrane met with in the walls of the hollow organs is of a **muscular** nature.

The *muscular* membrane is formed of unstriped fibres, the slow contraction of which is involuntary. In certain organs—those adjoining the natural apertures—the unstriped fibres are replaced by striped, which are under the influence of the will, or have the same physiological and reflex properties as the smooth fibres—as in the œsophagus.

(*Unstriped* or *smooth* bands of muscles are composed of long fusiform cells with staff-shaped, elongated nuclei, the cells varying from $\frac{1}{1125}$ to $\frac{1}{50}$ of an inch in length, and from $\frac{1}{5625}$ to $\frac{1}{1125}$ of an inch in breadth.)

c. When the organs are lodged in one of the great splanchnic cavities, such as the chest or abdomen, they have a third membrane—a **serous** layer, which lines the cavity, and is reflected around the viscera contained in it, so as to envelop them more or less completely. This layer has, therefore, an adherent face, applied either against the walls of the cavity or the external surface of the splanchnic organs; and a free face, always in contact with itself.

Fig. 214.



FUSIFORM CELLS OF SMOOTH MUSCULAR FIBRE.

a, Two cells in their natural state, one showing the staff-shaped nucleus; *b*, a cell with its nucleus, *c*, brought distinctly into view by acetic acid.

A *serous membrane* is composed of two layers: a deep, connective portion, analogous to the mucous corium; and a superficial, which is only tesselated epithelium. The free surface of this epithelium is perfectly smooth, and lubricated by a limpid *serosity* to facilitate the gliding of the parts the membrane covers. (The epithelium is a simple tesselated layer of flattened and polygonal nucleated cells, about $\frac{1}{1200}$ of an inch in diameter.)

2. The SOLID ORGANS are either contained in the splanchnic cavities or situated outside them, in the midst of connective tissue, which, in becoming more dense around them, often forms a fibrous covering.

Like the hollow organs, they are single—*spleen*, *liver*; or in pairs—*kidneys*; and symmetrical or asymmetrical in shape. They are retained in their *situation* by their vessels and nerves, by adherence to the neighbouring organs, or by particular serous bands.

With the exception of the lungs of animals that have respired, all the solid organs have a *density* greater than water. Their *weight* and *volume* offer numerous differences, which are individual, or peculiar to the species to which they belong. Nevertheless, each organ possesses a certain volume and weight which might be termed physiologic; when the organ is above or below this average, we are warranted in saying that it is in a pathological condition.

Solid organs are more or less round in *form*, and their surface is traversed by a variable number of furrows, which indicate their division into lobes or lobules.

Their *colour* is diverse; they may be very pale—*parotid gland;* or very dark —*liver*, *spleen;* or uniform, or of different shades—varieties which are most frequently due to the mode of distribution of the vessels, or to the presence of certain anatomical elements. The colour of organs is not always the same in the deeper parts and at the surface, especially when they are enveloped by a thick, opaque membrane—for instance, the *testicle.* Lastly, the coloration is less intense after death than during life, and particularly if the animal to which the organs belonged has been killed by effusion of blood.

The *consistence* of organs depends on their internal formation, and the nature of their constituent elements; there are soft organs—such as the *lungs*, and resisting organs—as the *testicles.* As a general rule, the consistency of organs diminishes after putrefaction has set in.

Cohesion is the resistance that organs offer to the forces which tend to tear them; it depends upon the texture of the organs, and the more or less abundance of fibrous and elastic tissue in their structure. Cohesion is very different from consistency; thus, such an organ as the lung may be easily compressed, but may be very difficult to tear.

If organs are examined with regard to their *structure*, it will be observed that all have a thin or thick fibrous covering, which throws septa into their interior, and which support their proper tissue; this tissue varies with the nature of the organs. It will also be found that they are traversed by a more or less considerable number of *blood-vessels*—arteries and veins. These vessels expand into a capillary network, the meshes of which have a shape closely allied to that of the elements of the proper tissue. The number and volume of the vessels of an organ give an exact idea of its importance, and of the activity of the physiological phenomena taking place in it. Finally, into the composition of organs enter superficial and deep *lymphatic vessels* and *nerves*, which generally follow the arteries. The nerves show in their course small ganglionic enlargements.

All the solid organs are either **glands**, or are apparently glandular. The function of *glands* is to elaborate or eliminate certain fluid or semifluid products, which, thrown out in hollow organs, are absorbed by their internal surface, or excreted.

The very *simple* (or *tubular*) *glands* consist of a straight or convoluted tube, or of a small vesicular cavity opening on a tegumentary membrane; they are lined on their inner face by one or more layers of cells. As an example, there may be cited the tubular glands of the stomach and intestines.

But there are also *conglomerate glands*—organs more complex, but which are merely masses of simple glands. There are tubular glands, like the *kidneys* and *testicles;* racemose glands, such as the *salivary glands* and *pancreas;* or a network of glands, like the *liver.* In these the essential anatomical element—the polygonal, cylindrical, or spherical gland-cell—is situated on the inner face of a tube—as in the *kidney*; or a vesicle, as is seen in the *pancreas*; or deposited without any order in the meshes of a plexus of canaliculi, as occurs in the *liver*.

The conglomerate glands are provided with a common excretory duct, that commences in their mass by a great number of arborescent ramifications. The walls of this duct are composed of an elastic, and sometimes contractile, connective tissue membrane, covered on its inner face by an epithelium, which may or may not be of the same character as that of the gland.

For a long time there have been classed as glands certain organs without excretory ducts, and having only analogies to glands. The majority of these belong to the lymphatic apparatus, and will be considered hereafter; but it may be mentioned here that they are all composed of masses of cells; some are small and simple—these are the *closed follicles*, solitary or agminated, and dispersed beneath the intestinal mucous membrane; the others are more complex and voluminous, and form *lymphatic glands*.

To the vascular system, but more particularly to the lymphatic apparatus, are annexed other glandiform organs, the fundamental structure of which, analogous in principle to that of the lymphatic glands, is, nevertheless, distinguished from them by certain peculiarities—such are the *spleen*, *thymus gland*, and *thyroid body*.

This is the limit to which the generalities relating to the viscera that form the object of splanchnology, must be confined. We will now pass to a description of the digestive apparatus in Mammals.

CHAPTER II.

THE DIGESTIVE APPARATUS IN MAMMALIA.

We will study, successively: 1. The *preparatory organs*, which include the *mouth*, the *salivary glands* annexed to that cavity, the *pharynx*, and the *œsophagus*. 2. The *essential organs*, comprising the *stomach* and *intestine*, and their *annexes*—the *liver*, *pancreas*, and *spleen*; with the *abdominal cavity*, which contains and protects these organs.

Article I.—Preparatory Organs of the Digestive Apparatus.

The Mouth.

The mouth—the first vestibule of the alimentary canal—is a cavity situated between the two jaws, elongated in the direction of the larger axis of the head, and having two openings: an anterior, for the introduction of food, and a posterior, by which the aliment passes into the pharynx.

The mouth should be studied in six principal regions: 1. The *lips*, which circumscribe its anterior opening. 2. The *cheeks*, forming its lateral walls. 3. The *palate*, which constitutes its roof or superior wall. 4. The *tongue*, a muscular appendage, occupying its inferior wall. 5. The *soft palate* (*velum pendulum palati*), a membranous partition situated at the posterior extremity of the buccal cavity, which it separates from the pharynx, and concurs in the formation—by a portion of its inferior face and border—of the *isthmus of the fauces*, or posterior opening of the mouth. 6. The *dental arches* fixed on each jaw.

We will study each of these regions in particular, before passing to the examination of the mouth in general.

Preparation.—The whole of the mouth ought to be examined in an antero-posterior and vertical section of the head (see description of the soft palate).

1. The Lips (Fig. 168).

These are two membranous movable folds, placed one above the other below the anterior opening of the mouth, which they circumscribe. There is, consequently, a **superior** and an **inferior lip**, united at each side by a *commissure.*

Each lip offers for study an external and internal face, and a free and an adherent border.

The *external surface* is convex, and presents, on the median line : in the upper lip, a slight projection which divides it into two lateral lobes ; in the inferior lip, and altogether posteriorly, the single prominence named the *tuft of the chin.* This face, formed by the skin, is garnished with fine, short hairs, amongst which may be remarked long, coarse bristles, the roots of which are implanted perpendicularly in the integument, and pass beyond its deep surface, to be lodged in the subjacent muscular tissue. These pilous tentacles ought to be considered as real tactile organs, because several sensitive nerve-filaments penetrate to the bottom of their follicles, and they have a very remarkable vascularization.

The *internal surface,* constituted by the buccal mucous membraue, and moulded on the incisor teeth, is concave, smooth, rose-coloured, and often stained with black spots. In the superior lip, particularly, may be remarked numerous orifices opening on the summits of three small papillæ ; these are the openings of the excretory canals, by which the labial glands discharge their fluid into the interior of the mouth.

The *free border,* thin and sharp, shows the line of demarcation that separates the two teguments.

The *adherent border* is limited, in the buccal cavity, by a groove formed by the mucous membrane in passing from the incisor arches to the inner side of the lips. Beyond the mouth it is not indicated by any peculiarity of structure or arrangement, the skin being continued directly from the neighbouring parts on the lips.

The *commissures* mark, on each side, the point of union between the free borders of the two lips. They are rounded in Solipeds, and offer nothing remarkable otherwise.

Structure.—Each lip is composed of two tegumentary layers : one *cutaneous,* the other *mucous,* between which is found *muscular tissue* and *glands,* and the general elements of every organization—*vessels* and *nerves.*

1. *Tegumentary layers.*—The *skin* adheres closely to the subjacent tissues, and apart from the characters already indicated, there is nothing more to be said at present with regard to its disposition, as it will be studied more completely with the organs of sense. With regard to the *mucous membrane,* it may be remarked that its dermis is thick and dense, and lies on a layer of salivary glands ; it is provided with simple conical papillæ, and is covered by stratified tesselated epithelium. (It is sometimes streaked with pigment.)

2. *Muscles.*—These are : the *labialis* or *orbicularis oris*—the sphincter of the buccal aperture, and common to the two lips ; in the upper lip, the aponeurotic expansion of the *levator labii superioris proprius,* the musculo-fibrous tissue which

separates this expansion from the cutaneous integument, and the terminal insertion of the *levator labii superioris alæqui nasi* and the *dilator naris lateralis* ; in the inferior lip, the *tuft of the chin* and its suspensory muscles—the *levatores menti.* All these muscles having been studied in detail in the *Myology* (p. 274), there is no necessity for their being again described.

3. *Labial glandules.*—These form an almost continuous layer between the mucous membrane and the orbicularis muscle. They are small secretory organs, similar in their structure and uses to the salivary glands, and will be described when these come under notice.

4. *Vessels and nerves.*—The blood is carried to the lips by the *palato-labial*, and the *superior* and *inferior coronary arteries.* It is returned to the heart by the satellite *veins* of the two last vessels. The *lymphatics* are very numerous, and pass to the glands between the branches of the lower jaw. The *nerves* are of two kinds : the motor, which are given off from the facial nerve, and are distributed in the muscular tissue of the lips to cause its contraction ; the sensitive nerves—from the maxillary branches of the fifth cranial pair—are distinguished by their number and considerable volume, and are nearly all distributed to the cutaneous integument, which they endow with an exquisite sensibility.

Functions.—The lips serve for the prehension of solid and liquid food ; they retain it in the mouth after its introduction thereto, and they prevent the escape of the saliva. They ought also to be regarded—especially the upper lip—as very delicate tactile organs.

2. The Cheeks (Fig. 168).

These are two membranous walls, which enclose the mouth laterally. In the interior of the buccal cavity they are limited : behind, by the posterior pillars of the tongue ; in front, by the lips, with which they are confounded around the commissures ; above and below, by the furrow formed by the gingival mucous membrane, where it is reflected from the molar arches on to the cheeks.

The greatest diameter of the cheeks is antero-posterior, like that of the cavity it encloses. The vertical diameter is very small, especially behind ; anteriorly, however, the cheeks assume a certain amplitude by the separation of the jaws.

Structure.—The cheeks are formed by the *buccal mucous membrane*, external to which we find *muscular tissue* and *glands. Vessels* and *nerves* are supplied for the conveyance of nutritive fluids, sensibility, or the stimulus to contractility.

1. *Mucous membrane.*—The external face of this membrane is closely attached to the buccinator muscle, and to the inferior molar glands. Its free face presents, at the level of the third upper molar tooth, the buccal opening of the parotid duct, at the summit of a variably-sized tubercle. On the face of each dental arch there is also remarked a linear series of little salient points, analogous to the large parotideal tubercle ; these are the excretory orifices of the molar glands. Its structure is the same as the mucous membrane of the lips. (It is of a pale colour, and sometimes stained in patches with pigment.)

2. *Muscular tissue.*—This is the buccinator or alveolo-labialis muscle already described. It may be remembered that the external face of this muscle is covered by the masseter, the superior molar glands, and the skin ; while the internal responds to the mucous membrane and the inferior molar glands.

3. *Glands.*—These are two masses of glandular lobules, known as the *molar glands.* They will be described with the salivary glands.

Vessels and nerves.—The *external maxillary*, *coronary*, and *buccal arteries* carry blood to the cheeks. The *veins* empty themselves into the satellite branches of these arteries.

The *lymphatics* proceed to the submaxillary glands. The *nerves* are of the same kind, and proceed from the same source, as those supplying the lips: being the seventh pair of cranial nerves for the muscular layer, and the fifth pair for the integuments (with filaments of the sympathetic for the blood-vessels and labial glands.)

FUNCTIONS.—The cheeks are very active agents in mastication, by constantly pushing the aliment, through the action of the buccinator, between the dental grinding surfaces.

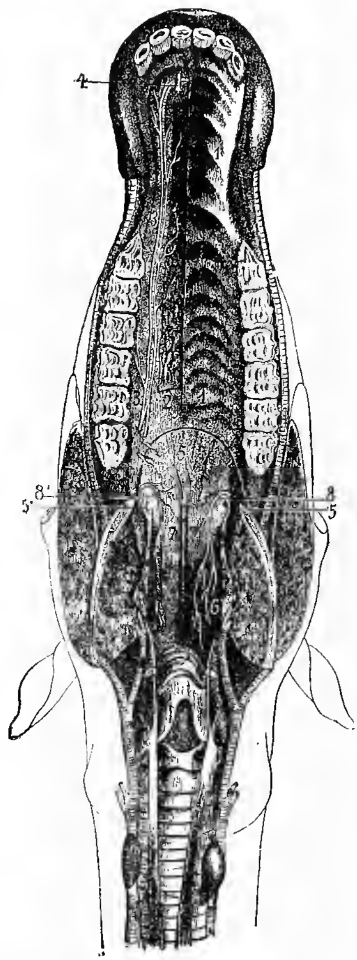
3. THE PALATE (Fig. 215).

Preparation.—Separate the head from the trunk; saw through the branches of the inferior maxilla above the angle of the jaw, and from the crown of the last molar tooth, so as to pass between the curtain of the soft palate on the one part, and the base of the tongue on the other, leaving the latter organ adherent to the lower jaw. This last should be removed from the upper jaw by cutting through the masseter and buccinator muscles, and so exposing the hard and soft palates in such a manner as to render easy the special dissections necessary for their study. For the palate, these dissections are limited to the removal of the mucous layer covering the deep venous network, and to the partial excision of this, which allows the artery and palatine nerves to be seen (see Fig. 215).

The *palate* (*hard palate*), *palatine arch*, or *upper wall of the mouth*, is circumscribed, in front and on the sides, by the superior dental arch, and limited, behind, by the anterior border of the soft palate. It is a parabolic surface, exactly representing, in its configuration, the bony palate (Fig. 50).

On its surface is remarked a median groove, which partitions it into two equal divisions, and which commences quite in front, at the base of a small tubercle. Curved transverse furrows, twenty in number (Leyh gives from sixteen to eighteen), divide each of these halves into an equal number of salient arches, the concavities of which are turned backwards, and which become narrower and less marked as they are more posterior. (These arches and furrows aid in retaining the aliment which the tongue carries towards the palate during deglutition.)

Fig. 215



THE HARD AND SOFT PALATE OF THE HORSE.

The mucous membrane has been removed from the right side, and, with the glandular layer, from the soft palate. 1, The ridges of the palatine mucous membrane; 2, venous network of the deep layer, which is incised at the external side to show the palatine artery, 3, accompanied by the filaments of the palatine nerve; 4, cartilaginous digitation, over which passes and is inflected the palatine artery; 5, aponeurosis of the soft palate; 5′, terminal extremity of the tendon of the tensor palati, forming by its expansion the staphyline aponeurosis; 6, the pharyngo-staphylinus; 7, the palato-staphylinus; 8, staphyline nerves.

Structure.—The palate lies on the bony vault formed by the palatine and supermaxillary bones. It includes in its structure :

1. A fibrous membrane, applied to the bone just mentioned, which sustains a remarkably developed venous network, constituting a veritable erectile tissue, and gives to the palate a greater or less degree of thickness, according to its state of turgescence (Fig. 215, 2).

2. A mucous layer, extremely adherent, by its deep face, to the preceding tissue, and of a whitish aspect in the horse. The corium, formed entirely of connective tissue, shows numerous conical papillæ, especially at the posterior part of the palate. The epithelium fills up the depressions between the papillæ ; it is stratified, squamous, and remarkable for the great thickness of its horny layer.

3. Two voluminous *arteries*—the *palatine*—are lodged in the bony fissures of the palatine roof. These arteries proceed parallel to each other, and unite in front by anastomosing to form a single trunk, which enters the incisive foramen. It is of importance to know their disposition, from a surgical point of view, as care ought to be taken not to wound them when abstracting blood from the palate. The blood carried by these arteries arrives in the deep-seated erectile membrane, and is finally removed by two very short *venous trunks*, which do not pass with the palatine arteries into the palatine canal, but only into the palatine fissure.

4. Sensory *nerves*, which accompany the arteries, and are derived from the superior maxillary branch of the fifth pair of cranial nerves.

Functions.—The palate has a passive, but important, share in mastication and deglutition ; furnishing the tongue, as it does, with a firm basis in the movements it executes when passing the food between the molar teeth, and in carrying the alimentary mass backwards to the pharynx.

4. The Tongue (Figs. 221, 223, 251, 306).

Preparation.—1. By means of a strong saw without a back, make an antero-posterior and vertical section of the head, in order to study the general disposition of the tongue. 2. From another head remove the lower jaw, leaving the tongue in the intermaxillary space, to examine the external conformation of the organ (see the dissection of the palate). On a third head, kept for the study of the muscles, these parts are exposed in the following manner: The masseter is entirely removed, and the cheek is detached from the lower jaw and turned over on the upper jaw ; then the branch of the inferior maxilla is sawn through transversely, at first behind, next in front of the molar teeth : the upper piece of bone should be detached by disjointing it behind the temporo-maxillary articulation, after destroying the capsular ligament and dividing the insertions of the pterygoid muscles. With regard to the inferior piece, it is reversed in such a way as to put the line of the molars downwards, and the inferior border of the bone upwards in the bottom of the intermaxillary space. To do this, it is sufficient to separate the buccal mucous membrane from the mylo-hyoideus muscle, proceeding from above to below. The dissection thus prepared, serves not only for the study of the muscles of the tongue, but also for those of the deep salivary glands, the pharynx, larynx, guttural pouches, the nerves and arteries of the head, etc. It is always better, in order to facilitate this dissection, to keep the jaws apart by fixing a piece of wood or bone between the incisor teeth immediately after the death of the animal.

The lingual canal.—The inferior wall (or floor) of the mouth, circumscribed by the lower alveolar arches, forms an elongated cavity named the *lingual canal* (or *space*), which lodges the organ designated the tongue. This canal occupies, in its anterior third, the superior surface of the body of the inferior maxilla. For the remainder of its extent, it is formed by a double groove in the floor of the mouth, at the sides of the tongue. It exhibits the *sublingual crest* and the *barbs*, of which we will speak when describing the sublingual and maxillary glands.

Situation of the tongue.—The tongue occupies the whole length of this elongated cavity, and thus extends from the back part of the mouth to the incisor teeth, lying in the intermaxillary space, where it rests on a kind of wide sling formed by the union of the two mylo-hyoidean muscles (see Fig. 307, 7).

External conformation.—It is a fleshy organ, movable in the interior of the buccal cavity, and almost entirely enveloped by the mucous membrane which lines that cavity. In Solipeds, it forms a kind of triangular pyramid, flattened on each side, fixed to the os hyoides and the inferior maxilla by the muscles which form the basis of its structure, or by the membrane that covers the organ.

Its form permits it to be divided, for the study of its exterior, into *three faces*, *three borders*, and *two extremities.*

The *superior face*, or *dorsum* of the tongue, narrower in front than behind, is roughened by numerous papillæ which give it a downy aspect. Two of these papillæ are remarkable for their enormous volume, their lobulated appearance, and the situation they occupy at the bottom of two excavations placed side by side, near the base of the organ—the *lingual lacunæ*, or *foramen cæcum of Morgagni.* This face corresponds to the palatine arch or roof, when the jaws are together. The *lateral faces*, wider in the middle of the tongue than at its extremities, are limited by the internal surfaces of the inferior maxillary branches. On them are seen several large papillæ, and the orifices of the *lingual glandulæ.*

These two faces are separated from the former by *two lateral borders*, which correspond to the superior alveolar arches when the mouth is exactly closed. With regard to the third or *inferior border*, its existence may be said to be fictitious ; by it enter the muscles which constitute the substance of the tongue, and it is by it, also, that the organ is fixed at the bottom of the intermaxillary space.

The *posterior extremity*, or *base* of the tongue, is limited, in the interior of the mouth, by a furrow which borders the base of the epiglottis. It presents a thick, median, mucous fold, plaited in different ways, and carried over the anterior aspect of the epiglottic cartilage. Two other folds, more anterior, also formed by the buccal membrane, unite with the soft palate on each side of the base of the tongue ; these are the *posterior pillars* of the organ (or the *glosso-epiglottic ligaments* of Man), and comprise in their substance a voluminous collection of glands. Behind these pillars are two triangular spaces, included between the velum pendulum palati and the base of the tongue, each of which has an excavation perforated with openings—a veritable *amygdaloid cavity*—which represents the *amygdalæ* (*tonsils*) of Man and the Carnivora ; it is a kind of common confluent for the numerous glandulæ accumulated outside the mucous membrane that lines this excavation.

The *anterior extremity* of the tongue is quite free, from the middle of the interdental space, and moves at liberty in the interior of the buccal cavity : it is also termed the *free portion* of the tongue, in distinction to the remainder of the organ, which is named the *fixed portion.* This free portion is flattened above and below, and slightly widened or spatulated. Its superior face is plane, or nearly so, and prolongs that of the fixed portion. The inferior, slightly convex, and perfectly smooth, is continuous with the lateral faces of the organ, and rests on the body of the inferior maxilla ; it is fixed to that bone by a median fold of mucous membrane—the *anterior pillar*, or *frænum linguæ.*

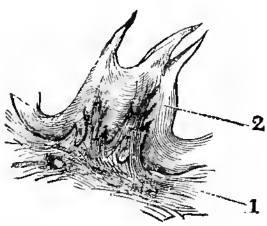
The borders, in joining each other in front, describe a parabolic curve which is in contact with the incisive arches.

STRUCTURE.—The tongue offers for study, in regard to its structure: 1. The *mucous membrane* enveloping the organ. 2. The *muscular tissue* which, in reality, forms its mass. 3. The *vessels* and *nerves* distributed to it.

1. *Mucous membrane.*—This membrane—a continuation of that lining the mouth—is reflected at the bottom of the canal on the sides of the tongue, covers the upper surface of the organ, and envelops the whole of its free portion. Its dermis, or corium, has not the same thickness throughout, but is incomparably thinner and less dense on the sides of the fixed portion and the inferior plane of the free part; on the dorsum of the tongue it is difficult to cut it. Its deep face receives the insertion of a large number of the muscular fibres of the organ, and for the greater part of its extent it adheres in the most intimate manner to these fibres, though its adherence is not so close at those points where it is in contact with the labial glands.

Its superficial face is not smooth, but shows a prodigious quantity of minute

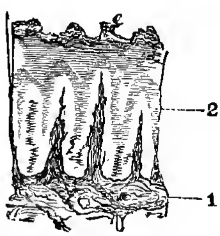
Fig. 216.



COMPOSITE PAPILLA FROM THE TONGUE OF THE DOG.

1, Corium; 2, epithelium.

Fig. 217.



SIMPLE FILIFORM PAPILLÆ FROM THE POINT OF THE HORSE'S TONGUE.

1, Corium; 2, epithelium.

prolongations or *papillæ*, which, according to their shape, are distinguished as *filiform*, *fungiform*, and *calyciform papillæ*.

The *filiform papillæ* (Fig. 217) are formed by thin prolongations terminating in a point, each being covered by an epithelial sheath which greatly increases its dimensions. They are simple or composite, having at their summit secondary prolongations, much smaller, and provided also with an epithelial covering. These filiform papillæ are largest on the middle part of the dorsum of the tongue, where they present a tufty appearance; towards the point of the organ they are embedded in epithelium, and are scarcely apparent in the minute elevations on its surface.

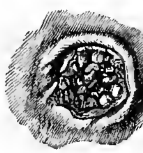
The *fungiform papillæ* (*p. capitatæ*) (Fig. 219, 2) are club or sponge-shaped elevations of the derm, attached to the membrane by a short pedicle. Their surface is convex and smooth, or studded with filiform papillæ. They are scattered irregularly over the dorsum of the tongue, among the filiform papillæ, and are most numerous on the posterior third of its surface.

The *calyciform papillæ* (*fossulate*, *circumvallate*, or *lenticular papillæ*) (Fig. 219) are really fungiform, but instead of projecting above the free surface of the dermis, they are placed in a depression in this membrane. They are surrounded by a slightly elevated ring, within which is a narrow fossa around the pedicle of the papilla; several papillæ may be contained within one cup-shaped cavity. They only exist at the base of the tongue, where two of their number, very developed and composite, correspond to the *blind foramina of Morgagni* (*foramen cæcum*). At the base of a certain number of the fungiform and calyciform papillæ is a band of adenoid tissue.

It is generally believed that these three kinds of papillæ have each a distinct function; the filiform are to retain the alimentary and sapid substances on the surface of the tongue, the fungiform are tactile organs, and the calyciform are gustatory.

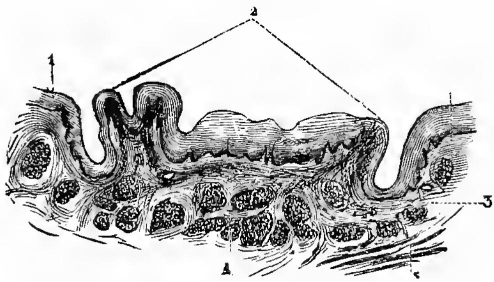
2. *Muscles.*—Beneath the mucous membrane, on the dorsal surface of the tongue, is a cylindrical fibrous cord, which sometimes attains the thickness of a large goose-quill. This cord is situated in the median plane, near the middle part of the organ, and is from 2 to 3 inches long. It may be considered as a fibrous support to the muscular tissue, and it sometimes directly adheres to the deep surface of the mucous membrane. At other times, it is only connected

Fig. 218.



FORAMEN OF MORGAGNI IN THE HORSE'S TONGUE (SEEN FROM ABOVE).

Fig. 219.



VERTICAL SECTION OF A FORAMEN CÆCUM OF THE HORSE'S TONGUE.

1, 1, Borders of the calyx; 2, fungiform papillæ occupying it; 3, section of the ring of lymphoid tissue; 4, racemose glands; 5, muscular fibres of the tongue.

with that membrane by a very short lamellar prolongation, and is then buried a little deeper among the fibres of the superior muscular layer.

(The German hippotomists designate this the *cartilage of the tongue*. It is only found in Solipeds, and was first described by Brühl, who gave it this designation. Leyh states that it is composed of dense fibro-cartilage, surrounded by connective and adipose tissue; that it is from 4 to 7 inches long, and $\frac{3}{4}$ to 1 inch in thickness; and that it commences about an inch from the anterior appendix of the hyoid bone.)

A similar cord, but not so strong or well-defined, is sometimes found at the inferior surface of the free portion of the tongue.

Intrinsic muscles.—In studying the proper substance of the tongue in two sections—one vertical and longitudinal, the other transverse—there is seen, under the dorsal mucous membrane, a layer of red fibres, close in their texture, and very adherent to that membrane. Amongst these fibres, there are some which affect a longitudinal direction, but the majority are vertical or transverse, and all are interlaced in the most intimate manner. It appears as if this layer (the *lingualis superficialis* of Man) were perfectly independent of the other muscular fibres, the insertion of which it receives. It also forms a portion of those which writers have named the intrinsic muscles of the tongue, and which comprise a *superior* and *inferior*, a *transverse* and a *vertical lingualis* muscle, found on the inferior aspect of the free portion of the organ. An attentive examination, however, reveals that the fibres proper to this submucous layer are continuous with those which, coming from a point situated beyond the tongue, form the muscles named, in consequence, *extrinsic*, and that they are only the prolongations of these. This division of the tongue into two orders of muscular fasciculi does not, for this reason, possess the importance generally accorded to it.

Extrinsic muscles.—If the muscular fibres of the tongue appear to be one mass in the superior layer just referred to, it is not so when they are followed beyond this layer ; on the contrary, we see them separate from one another, and even admit between them—at least in the fixed portion—a certain amount of adipose tissue, which is particularly abundant towards the base, where it forms a mass called the *fatty nucleus of Baur* ; then they collect into fasciculi, or perfectly distinct muscles.

In Solipeds, these muscles number five pairs : 1. The *stylo-glossus*. 2. The *great hyo-* or *basio-glossus*. 3. The *genio-glossus*. 4. The *small hyo-glossus* (the *superior lingual* of some authorities). 5. The *pharyngo-glossus*.

Stylo-glossus (Hyo-glossus Longus) (Fig. 220, 1).

Synonym.—Kerato-glossus externus—Leyh. The ***stylo-glossus*** of Man.

This is a very long riband-shaped band, formed of bright-red parallel fibres, and extending from the styloid bone, or great cornu of the os hyoides, to each side of the free extremity of the tongue.

It arises from the external surface of the large cornu, near its inferior extremity, by a very thin aponeurosis ; it terminates near the tip of the tongue, in expanding over the inferior surface and borders of the organ, and mixes its fibres with those of the opposite muscle.

In the fixed portion of the tongue, this muscle is related : outwardly, to the mylo-hyoideus, sublingual gland, lingual nerve, and the Whartonian duct ; inwardly, to the genio-glossus and great hyo-glossus muscles. The whole of its free portion is covered by the buccal membrane.

In contracting, this muscle pulls the tongue towards the back of the mouth ; it inclines it to one side when acting independently of its fellow on the opposite side.

Great Hyo-glossus, Basio-glossus (Hyo-glossus Brevis) (Fig. 220, 2).

Synonym.—Hyo-glossus—Leyh.

A wide muscle, flattened on both sides, thicker than the preceding, and composed of fibres passing obliquely forward and upward, the longest of which are anterior.

Its origin occupies the whole side of the body of the os hyoides, from the extremity of the cornu to that of the spur process. Its fibres, after becoming detached from this point of insertion, are insinuated beneath the preceding muscle, spread out under the mucous membrane covering the lateral aspect of the tongue, and for the most part are reflected inwards, nearly to the superior face, to constitute the transverse fibres of the organ.

It is in relation, outwardly, with the mylo-hyoideus, stylo-glossus, the great hypo-glossal nerve, Wharton's duct, and the lingual mucous membrane ; inwardly, with the small hyo-glossus, the small cornu of the os hyoides, the pharyngo-glossus, genio-glossus, lingual artery, the terminal divisions of the glosso-pharyngeal nerves, and great and small hypo-glossals.

It retracts the tongue in depressing its base, according as it acts singly or simultaneously with its fellow.

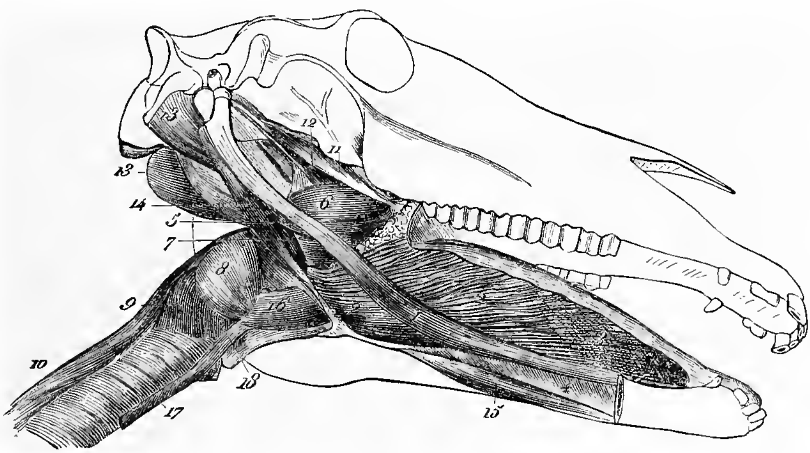
(In 1850, Brühl described as the *middle descending stylo-glossus*, a long, narrow muscle arising from the lower extremity of the inner face of the styloid bone, or large cornu of the os hyoides, and terminating near the tip of the tongue, where it is covered by the hyo-glossus. It has since been described as the internal or small kérato-glossus. Its action is the same as the stylo-glossus.)

Genio-glossus (Genio-hyo-glossus) (Fig. 220, 4).

This is a beautiful muscle, the fibres of which are disposed like a fan in the vertical and median plane of the tongue.

It arises from the inner surface of the lower jaw, near the symphysis, by a

Fig. 220.



MUSCLES OF THE TONGUE, SOFT PALATE, AND PHARYNX.

1, Stylo-glossus; 2, great hyo-glossus; 3, the same, covered by the submucous layer formed by the expansion of the small hyo-glossus; 4, genio-glossus ; 5, pharyngo-glossus ; 6, palato-pharyngeus ; 7, hyo-pharyngeus; 8, thyro-pharyngeus; 9, crico-pharyngeus; 10, œsophagus ; 11, 12, tensors palati; 13, stylo-hyoideus; 14, hyoideus magnus; 15, genio-hyoideus; 16, hyo-thyroideus; 17, sterno-thyroideus ; 18, crico-thyroideus.

tendon parallel to that of the genio-hyoideus. From this tendon are detached a multitude of divergent fibres which pass backwards, upwards, and forwards, to reach the upper surface of the tongue, and become continuous with the vertical fibres of the submucous layer.

The two genio-glossi lie together on the median plane of the tongue, except towards their origin, where they are constantly kept apart by adipose tissue. Their inferior border responds to the genio-hyoid muscles, and their anterior fibres are partly included between the two mucous layers of the frænum linguæ. They are related, by their external face, to the great hyo-glossus, the stylo-glossus, the sublingual gland, the lingual artery, and the terminal branches of the three lingual nerves.

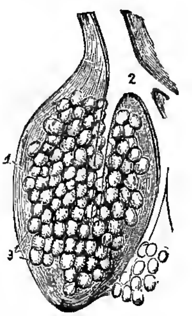
The action of the genio-glossus is complex ; according to the portion of its fibres which contract, it will carry the tongue forwards, pull it into the buccal cavity, or draw it downwards into the floor of the mouth.

Small Hyo-glossus (Lingualis) (Fig. 220, 3).

Synonym.—Lingualis superior of Man.

Under this name is described a thin band, formed of parallel fibres, which is exposed immediately on removing the mucous membrane, with the subjacent glands, from the base of the tongue. This band arises from the inner side of the articulation uniting the body of the os hyoides to its small cornu. It passes

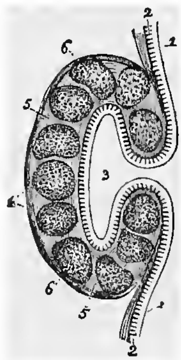
Fig. 221.



ONE LOBE OF A RACEMOSE GLAND.

1, Envelope of connective tissue ; 2, excretory duct ; 3, glandular vesicle, or acini.

Fig. 222.



FOLLICULAR GLAND FROM THE ROOT OF THE TONGUE.

1, Epithelium ; 2, papillæ of mucous membrane ; 3, cavity of the follicle ; 4, investing coat of the gland composed of connective tissue ; 5, fibro-vascular matrix, forming its parenchyma, and containing, 6, 6, the closed capsules or follicles.

above the transverse muscle of that bone, which it crosses perpendicularly, is surrounded at this point by a great mass of adipose tissue, and is prolonged directly forward, beneath the lingual mucous membrane. Its fibres then vanish, either on the superior aspect of the tongue or on its sides, or they descend obliquely in crossing the direction of the hyo-glossus, to join the superior border of the stylo-glossus.

(This muscle contracts and retracts the tongue.)

Pharyngo-glossus (Palato-glossus) (Fig. 220, 5).

A rudimentary muscle formed of parallel fibres, which, from their origin on the lateral wall of the pharynx, pass outside the articular angle of the branches of the os hyoides, and between the hyo-glossus and genio-glossus, mixing with, and intercrossing their fibres.

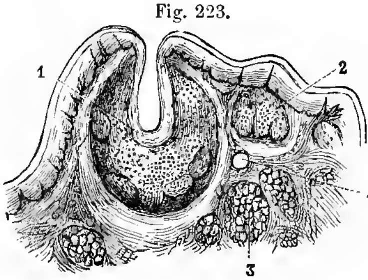
3. *Labial glands.*—The numerous glands of the tongue may be divided into racemose (or lobulated) glands, and closed follicles (or follicular glands).

The *racemose glands* (Fig. 221) are spread on the sides and base of the tongue. Near its upper border they form two rows, which are rendered visible by the presence of a small tubercle placed beside each of them. At the base of the tongue they are found beneath the fungiform and calyciform papillæ, as well as beneath the layer of closed follicles which lines the isthmus of the fauces.

At the entrance to this passage, the lingual mucous membrane is mammillated, and each elevation has an orifice. This arrangement is connected with the presence, at this part of the tongue, of the *closed follicles* (Figs. 222, 223), which are more or less voluminous and aggregated, and separated from the muscles by a continuous layer of racemose glands. They are composed of an envelope of dense connective, and a mass of adenoid tissue, which has in its centre a cavity that communicates with the orifice above the follicle, and is lined by the lingual epithelium, *minus* its horny layer.

4. *Vessels and nerves.*—The tongue is supplied with blood by two arteries, the *lingual* and *sublingual;* the blood is removed by three large veins, two of which enter the *external maxillary*, and the third the *internal maxillary vein*. The *lymphatics* constitute a very fine superficial network, the emergent branches of which pass to the submaxillary glands. The *nerves* are the lingual, the glosso-pharyngeal, and the great hypo-glossal; the latter is a motor nerve, and consequently supplies the muscles; the others are exclusively sensitive, and are distributed more particularly to the mucous membrane.

Fig. 223.



SECTION OF AN AMYGDALOID FOLLICLE OF THE HORSE'S TONGUE.

1, Follicle cut through the middle; 2, follicle divided beyond its centre; 3, section of a racemose gland; 4, vessel.

FUNCTIONS.—The tongue serves for the prehension of liquids in all animals, and for solid aliment in the Ox. It concurs, with the jaws, in propelling the substances to be crushed between the molar teeth during mastication; and it is, besides, one of the essential organs of deglutition. It is able to play this important and complex part, through the varied movements it can execute in the interior of the mouth; and the extent of these movements demands a moment's notice. They are of two kinds: those which influence only the form of the organ, and those which cause it to submit to various displacements. They result in either compressing it from side to side, above to below, or curving it longitudinally, and even transversely. These movements are principally, but not exclusively, due to the action of the intrinsic fibres; they are perfectly independent of the movements which, as a whole, produce the total displacement of the tongue. With regard to these latter, they may result in carrying the tongue beyond the mouth, or withdrawing it into that cavity, inclining it to one side, raising it against the palate, depressing it on the floor of the mouth, or, finally, lifting it towards the pharynx. It is worthy of remark that these movements do not alone result from the action of the proper lingual muscles above described; those belonging to the os hyoides, to which is attached the spur process, concur also in producing them. But this process is not the only organ thus attached to the hyoideal apparatus; the larynx and, through it, the pharynx, are placed in the same conditions, and are obliged to follow, like the tongue, the movements of the bony framework supporting them.

There consequently results, between these three organs, a remarkable unity of action, which is readily explained by the part they all take in the one common act of deglutition.

5. Soft Palate (Figs. 215, 224).

Preparation.—The soft palate is studied : 1. On the antero-posterior and vertical section of the head (Fig. 220). 2. On the portion inteuded to show the interior of the pharynx (see the preparation of this region). 3. On the portion represented in Fig. 215, the mode of dissecting which has been indicated at page 399; in removing the mucous membrane and glandular layer, the fibrous membrane and the two intriusic muscles are exposed. The extrinsic muscles should be studied with those of the pharynx.

Situation—Form.—The soft palate (*palatum molle*, *velum pendulum palati*) is suspended like a partition between the mouth and the pharynx, and by its posterior border circumscribes the orifice that establishes a communication between these two cavities.

This partition, which continues the hard palate posteriorly, represents in its external form a membranous valve, oblique downwards and ~~forwards~~ backwards, much longer than it is wide, and exhibiting for study *two faces* and *four borders.*

The *inferior* or *anterior face*, towards the mouth, shows longitudinal folds and transverse ridges, with multitudes of orifices belonging to the submucous glandulæ. On its sides it is united to the base of the tongue by means of two thick mucous columns, designated the posterior pillars of the tongue. The *superior* or *posterior face* forms the anterior wall of the pharynx ; it only exhibits some very slight longitudinal ridges.

The two *lateral borders* are inserted into the walls of the two cavities which the soft palate separates. The *anterior border*, continuous with the palate, is attached to the palatine arch, and follows the curve described by it. The *posterior border*—the only free one—is concave, and closely embraces the base of the epiglottis, which is usually found lying against the posterior surface of this curtain. This border is continued at its extremities by two thin prolongations, which can be followed on the lateral walls of the pharynx to the œsophageal infundibulum, above which they unite in the form of an arch. These prolongations are the *posterior pillars of the soft palate*, in contradistinction to the two mucous folds at the base of the tongue, which constitute, by their relation to this partition, veritable *anterior pillars.* This posterior border concurs in circumscribing what is named the *isthmus of the fauces*—an aperture constantly closed in Solipeds, in consequence of the great development of the soft palate; it is only dilated for the passage of the alimentary substances passing into the pharynx. The isthmus of the fauces is, therefore, not merely an opening ; it is a passage which has for its inferior wall the base of the tongue as far as the epiglottis ; for its upper wall, the anterior face of the soft palate ; and for its sides the posterior pillars of the latter.

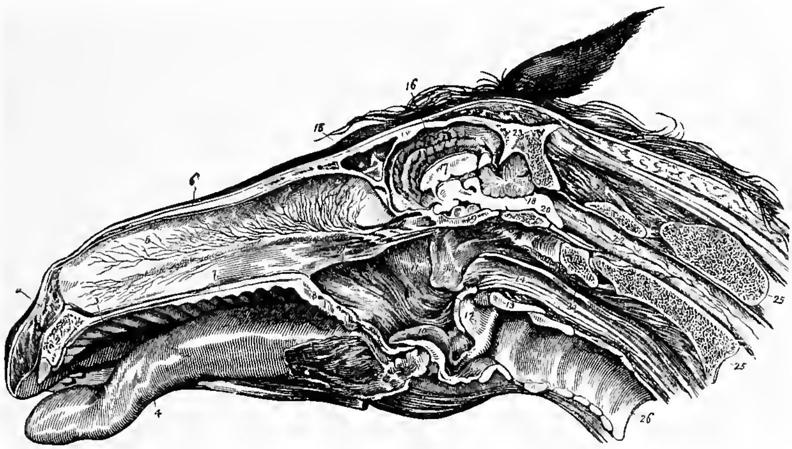
Structure.—To give the most simple idea of the structure of the soft palate, it may be said that the mucous membrane of the palate, and that of the floor of the nasal cavities, is prolonged behind the palatine arch, parallel to one another, and become joined towards the free border of this curtain ; and it might be further shown that, in the space between these two mucous membranes, there is a fibrous membrane, muscles, a glandular layer, vessels, and nerves; besides these, there are no other elements in the organization of the soft palate.

They may be studied in the following order: 1. *Fibrous membrane.* 2. *Muscles.* 3. *Mucous membranes.* 4. *Vessels and nerves.*

1. *Fibrous membrane* (Fig. 215, 5).—This membrane, remarkable for its power of resistance, forms a real framework for the soft palate, of which it only occupies the anterior moiety. It is attached in front of the palatine arch, and is prolonged posteriorly by a particular muscle, the palato-pharyngeus.

2. *Muscles.*—Of these muscles, which are all pairs, there are those which constitute a layer situated in the middle of the soft palate itself, and represent the *intrinsic muscles;* these are the *pharyngo-staphylinus* (*palato-pharyngeus*) and the *palato-staphylinus* (*circumflexus palati*). The others, the *peristaphylinus* —external and internal (*tensors palati external and internal*), are only inserted

Fig. 224.



MEDIAN LONGITUDINAL SECTION OF THE HEAD AND UPPER PART OF NECK.

1, Upper lip; 2, premaxilla; 3, hard palate; 4, tongue; 5, septum nasi; 6, nasal bone; 7, palatine arch; 9, pterygoid bone; 10, epiglottis; 11, entrance to the Eustachian tube; 12, arytenoid cartilage; 13, cricoid cartilage; 14, œsophagus; 15, frontal bone and sinus; 16, cerebrum; 17, corpus callosum; 18, cerebellum; 19, sphenoid bone; 20, medulla oblongata; 21, cervical ligament; 22, spinal cord; 23, occipital bone; 24, 24, atlas; 25, 25, dentata; 26, trachea.

into the organ by their terminal extremities, and therefore act as *extrinsic muscles.*

Pharyngo-staphylinus (Palato-pharyngeus) (Fig. 215, 6)

In removing the mucous and glandular layers which cover the anterior face of the soft palate, there is exposed a wide and thin muscular fasciculus succeeding the fibrous layer behind, and occupying the posterior half of the entire organ. The fibres of which this muscle is composed, mixed in the median line with those of the muscle of the opposite side, are directed backwards and outwards, the most posterior following the curve of the free border of the curtain. Arriving near the lateral border, they are reflected upwards, passing between the pharyngeal mucous membrane and the middle constrictor of the pharynx, with which it appears to be confounded posteriorly; but with a little attention it can be followed to the superior border of the thyroid cartilage, into which it is inserted, after making a somewhat long track under the mucous membrane of the pharynx.

This muscle stretches the curtain, and draws its free border from the œsophageal infundibulum, during pharyngeal deglutition.

Palato-staphylinus (Azygos Uvulæ) (Fig. 215, 7).

(*Synonyms*—Staphyleus—*Girard*. *Circumflexus palati*—*Percivall*. The *azygos uvulæ* of Man.)

A small, elongated, cylindrical, bright-red muscle, opposed, in the median line, to that of the other side, and extending over the inferior surface of the preceding, from the palatine arch to the free border of the soft palate, which it pulls forward and upward to dilate the isthmus of the fauces. It arises by a small glistening tendon, not from the palatine, but from the staphyline aponeurosis (Fig. 215, 7). The fascia which the two muscles form is for the most part covered, in its middle portion, by the fibres of the tensores palati.

Sometimes, and especially in the **Ass** and **Mule**, the fibres of this muscle are directly attached to the palatine arch, in becoming more or less insinuated into the substance of the glandular layer.

Peristaphylinus Externus (Tensor Palati) (Fig. 220, 11)

(*Synonym.*—The *circumflexus* of Man.)

This is a small, elongated muscle, flattened on both sides, bulging in its middle, thin and tendinous at its extremities, and extending obliquely forward and downward from the styloid process of the temporal bone, where it has its origin, to the pterygoid trochlea. Its terminal tendon glides and is inflected inwards on this pulley, to be afterwards spread out and confounded with the fibrous framework of the soft palate, which causes the framework to represent an expansion of the tendon.

The muscle is covered, outwardly, by the pterygoidei muscles; it is related, internally, to the next muscle, which separates it from the Eustachian tube.

It is a tensor and depressor of the aponeurosis of the soft palate.

Peristaphylinus Internus (Levator Palati) (Fig. 220, 12).

(*Synonyms.*—*Stylo-pharyngeus*—*Percivall*. The *levator paloti* of Man.)

This is formed by a pale and thin band, which arises with the preceding muscle, descends between it and the Eustachian tube, passes beneath the superior constrictor of the pharynx, then below the mucous membrane of the pharynx to reach the soft palate, where it expands on the anterior or posterior surface of the palato-pharyngeus, beneath the glandular layer, its fibres becoming mixed, on the median line, with those of its fellow.

This is an elevator of the soft palate.

3. *Glandular layer.*—This layer is comprised between the fibrous membrane and the anterior mucous layer, becoming thinner as it is prolonged over the intrinsic muscles; it does not extend to the free border of the organ. It is thickest on each side of the median plane, where it forms two lobes, which appear on the anterior surface of the soft palate as an elongated ridge, much more

marked in the **Ass** than the Horse. It is worthy of notice, that the glands composing this layer throw all their secretion into the mouth—that is, on the anterior face of the soft palate.

4. *Mucous membranes.*—The soft palate is covered on both its surfaces by two mucous layers, one anterior, the other posterior, united, as has been remarked, at the free border of the organ. The anterior is continuous, above, with the mucous membrane of the hard palate; on its sides, with that which covers the base of the tongue. In structure it is the same as the buccal membrane; its epithelium is stratified and tesselated. The other layer is nothing more than the pituitary membrane extended over the posterior surface of the septum, and thence to the lateral surfaces of the pharynx. It will be more fully described with the latter.

5. *Vessels and nerves.*—The soft palate is supplied with blood by the *staphyline* and *pharyngeal arteries.* The nervous filaments this partition receives, emanate from the fifth pair of cranial nerves (superior maxillary branch), and from Meckel's ganglion; they form the *staphyline* or *posterior palatine nerve* (Fig. 215, 8).

The superior maxillary branch is entirely sensitive, and yet the staphyline nerve goes to tegumentary, glandular, or contractile organs. How can it fulfil this double function? By receiving filaments from Meckel's ganglion, which has motor fibres derived from the facial nerve.

FUNCTIONS.—During the act of deglutition, the soft palate is raised to enlarge the isthmus, and allow solids or liquids to pass through. The description given of this septum, permits us to understand how it plays the part of a valve, in rising freely while the alimentary bolus or mouthful of fluid passes from the mouth into the œsophagus, across the pharyngeal vestibule, but never allowing the matters which have once entered the œsophageal canal to return into the buccal cavity. Also why, when any obstacle is opposed to the descent of aliment into the œsophagus, after it has cleared the isthmus of the fauces, or even when the animal vomits, the matters arrested in their passage or expelled from the stomach are ejected by the nasal cavities, after flowing over the posterior surface of the soft palate. This disposition of the pendulous curtain, in forming a complete partition which hermetically seals the orifice of communication between the mouth and pharynx, likewise sufficiently explains why, in normal circumstances, Solipeds respire exclusively by the nostrils.

6. THE TEETH.

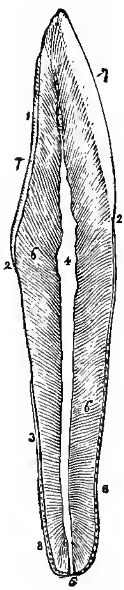
Passive agents in mastication, the *teeth* are hard organs, bony in appearance, implanted in the jaws, and projecting into the interior of the mouth, in order to bruise or tear the solid alimentary substances.

Identical in all our domesticated animals, in their general arrangement, their mode of development, and their structure, in their external conformation these organs present notable differences, the study of which offers the greatest interest to the naturalist. For it is on the form of its teeth that an animal depends for its mode of alimentation; it is the *régime*, in its turn, which dominates the instincts, and governs the diverse modifications in the apparatus of the economy; and there results from this law of harmony a striking correlation between the arrangement of the teeth and the conformation of the other organs.

Compelled by the limits of our task to confine ourselves to the purely descriptive part of the dental apparatus, we cannot stop to notice the interesting physiological considerations on which this principal is founded; but will begin at once the anatomical study of the teeth, by indicating their general characters, before examining them successively in all the domesticated species.

A. GENERAL CHARACTERS OF THE TEETH—**General Arrangement.**—The teeth are fixed in the jaws, and ranged one against the other in such a way as to form two parabolic arches opening behind, and interrupted on each side by what is called the interdental space. Distinguished into superior and inferior, like the jaws to which they belong, these arches come in contact with one another in a more or less exact manner when the mouth is perfectly closed.

Fig. 225.



MAGNIFIED SECTION OF A CANINE TOOTH, SHOWING ITS INTIMATE STRUCTURE.

1, Crown; 2, 2, neck; 3, fang, or root; 4, cavitas pulpæ; 5, opening by which the vessels and nerves communicate with the pulp; 6, 6, dentine, showing fibrous structure; 7, 7, enamel; 8, 8, cement.

Those teeth which are placed together in front, at the middle of the dental arches, are named *incisors*, or *incisive teeth;* the others, situated behind these, and always numbering two for each jaw, are called the *canine teeth*, or *tusks;* while the designation of *molars* is given to those which occupy, in the more retired portion of the buccal cavity, the lateral parts and extremities of the dental arches.

External Conformation.—Each tooth represents, when completely developed, an elongated polyhedron, which has sometimes a pyramidal form, and at others that of a cone or parallelopiped.

A portion of the tooth is buried and solidly implanted in one of the alveolar cavities of the maxillary bones; this is the *root*, or *embedded portion* (or *fang*). The other portion, circumscribed at its base by the gum, leaves the alveolus to project into the interior of the mouth, forming the *crown*, or *free portion*. The narrow constriction between the crown and root is named the *neck*.

The *fang* is perforated at its inferior extremity by one or more excavations (*cavitas pulpæ*), which penetrate deeply into the substance of the tooth, and admit into their interior the vasculo-nervous papilla, simple or ramified, known by the name of the *bulb*, or *dental pulp*.

The *crown*, the portion submitted to friction during mastication, and, consequently, to wear, offers the most varied forms: sometimes it is shaped like a very acute cone; at others, it is divided into several tubercles more or less salient; and sometimes, again, it bears at the extremity of the tooth a wearing surface more or less plane and regular.

Structure.—Three essentially different substances enter into the structure of all the teeth—the *ivory*, *enamel*, and *cement;* to which ought to be added the soft parts—the *pulp*, *gum*, and *alveolo-dental periosteum*.

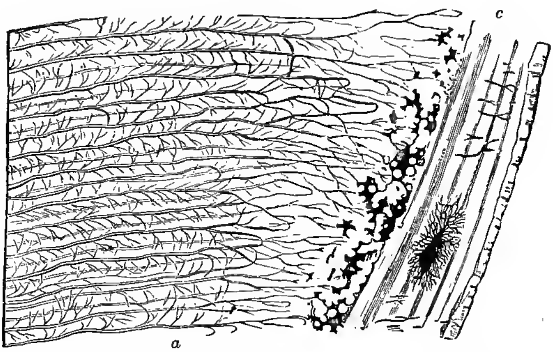
IVORY.—The *ivory*, or *dentine*, has the hardness of bone, is of a whitish-yellow colour, and is rendered brilliant in places by its nacrous reflection. It forms the principal mass of the tooth, enveloping everywhere the pulp cavity.

Examined by aid of the microscope, this substance is found to be channeled by a multitude of minute, undulating, and branching canals (*dental canaliculi* or *tubuli*) embedded in amorphous matter (the *fundamental substance*).

The *tubuli*, or *canaliculi*, extend from the dental cavity to the inner face of the enamel; single at their origin, they soon bifurcate, and again anastomose several times during their slightly undulating course. They terminate in a *cul-de-sac*, or in irregular cavities situated beneath the enamel, and named the *interglobular spaces of Czermak* (forming the *interglobular* or *nodular layer*). These canals have a thin proper wall, and contain a dental fibre, which very probably is a continuation of the pulp-cells. The *fundamental substance* (or *matrix*) is amorphous, and not very abundant; in its mass are deposited the saline molecules which give the dentine its bony consistency. (These molecules are deposited in lamellæ, concentric with the pulp cavity. Nasmyth considers the fibres to be rows of minute opaque points, arranged in a linear series —*baccated fibres*—and to be merely the nuclei of the ivory cells, the interfibrous substance being the remainder of the cell filled with calcareous matter.)

Its chemical composition much resembles that of bones. After remaining

Fig. 226.



SECTION THROUGH THE FANG OF A MOLAR TOOTH.

A, *a*, Dentine traversed by its tubuli; *b*, *b*, interglobular, or nodular layer; *c*, *c*, cementum.

in dilute hydrochloric acid for several weeks, it comports itself like them, by giving up the calcareous salts with which it is impregnated to the acid solution; and becoming soft like cartilage; submitted to the action of boiling water, it yields gelatine. The mineral matters of dentine differ from those of bone in having a smaller proportion of carbonate of lime.

Enamel.—The *enamel* extends in a layer over the ivory of the free portion of the tooth, the exterior of which it entirely envelops; it is prolonged over the fang in some animals, and in several kinds of teeth it dips, by the crown, into the interior of the organ to a very great depth. It is brilliantly white, and so hard that it strikes fire like steel.

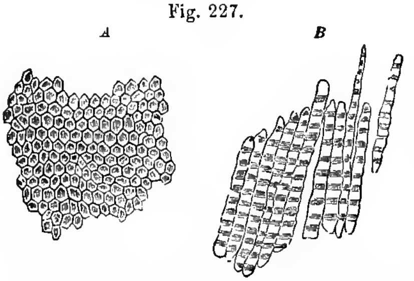
Its microscopic structure is very interesting, the enamel being composed of small prismatic hexagonal rods, $\frac{1}{5000}$ of an inch in diameter, and notched on their faces. Owing to this notching, the prisms are intimately united to each other. They form several layers which cross each other at an acute angle, though in each layer they are exactly parallel to one another. By immersing the enamel in dilute hydrochloric acid, there is detached from its surface a fine amorphous membrane (*cuticle of the enamel*).

(The chemical composition of enamel appears to be 96·5 per cent. of earthy matter, and 3·5 of animal substance. The first consists of phosphate of lime, with traces—3 per cent.—of fluoride of calcium, carbonate of lime, phosphate of magnesia, and other salts. The rods are directed vertically on the summit of the crown of the tooth, and horizontally at the sides.)

CEMENT (*cementum*, *substantia ostoidea*, *cortical substance*, or *crusta petrosa*).—The *cement* is spread in a non-continuous layer over the external surface of the enamel and dentine. It is accumulated in large quantity in the substance of some teeth, as will be noticed when speaking of the incisors in the Horse and the molars of the Herbivora.

The structure and properties of this substance differ in nothing from the structure and properties of the spongy tissue of bone. In a physiological condition, the cement does not contain any *Haversian canals*. (It contains, sparingly, the lacunæ and canaliculi which characterize true bone: those placed near the surface have the canaliculi radiating from the side of the lacunæ towards the periodontal membrane; and those more deeply placed join with the adjacent dental tubuli. In the thicker portions of the crusta petrosa, the lamellæ and Haversian canals peculiar to bone are also found. As age advances, the cementum increases in thickness, and gives rise to those bony growths, or exostoses, so common in the teeth of the aged; the pulp cavity also becomes partially filled up by a hard substance, intermediate between dentine and bone—*osteo-dentine*, or *secondary dentine*. It appears to be formed by a slow conversion of the dental pulp, which shrinks or even disappears.)

Fig. 227.



A, TRANSVERSE SECTION OF ENAMEL, SHOWING ITS HEXAGONAL PRISMS; B, SEPARATED PRISMS.

Dental pulp.—The *pulp*, or *papilla*, is formed by a fibrillar and nuclear mass that fills the internal dental cavity. It receives blood-vessels and nerves, and is enveloped in a very thin membrane which is entirely composed of several layers of beautiful cylindrical or prismatic cells, the most superficial of which send fibrillar prolongations into the dental tubuli. Towards the base of the papilla, this membrane assumes the texture of connective tissue, and is reflected upwards on the fang of the tooth to line the alveolus, and join the gum at the origin of the crown.

Gum.—The *gum* is a portion of the buccal mucous membrane surrounding the neck of the tooth; it concurs in consolidating it in the alveolar cavity. Its structure is that of the membrane to which it belongs, being a thick dermis furnished with papillæ and tesselated epithelium. It does not contain any glands.

Alveolo-dental periosteum.—This scarcely differs from ordinary periosteum, except in being a little softer. It lines the alveolus and covers the cementum of the fang.

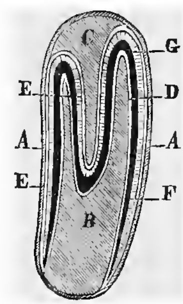
Development.—Each tooth is developed in the interior of a closed sac named the *dental follicle* or *sac*,[1] and lodged in an excavation in the maxillary bones. The sac presents, according to the species of animal and kind of teeth, numerous variations, which we cannot stay to consider here; but must confine ourselves merely to a brief sketch of the general and constant characteristics of its

[1] Two adjoining follicles and the papillæ they contain, sometimes join each other, for we have seen a two-years-old Ass in which the central and lateral incisors in the inferior maxilla were united, so as to form only two teeth, instead of four.

organization. (For details, see Embryology—*Development of the Digestive Apparatus.*)

The *dental follicle* is constituted by an external enveloping membrane of a cellulo-vascular nature (Fig. 228, A). It shows at its bottom the simple or compound papilla, which at a later period is termed the *dental pulp* (B); this organ, destined for the secretion of the dentine, then fills nearly the whole of the follicle. In its upper part is observed the *enamel organ*, or *germ* (*enamel membrane*), formed by a prolongation of the gingival epithelium, and connected with the latter by a small mass of cells named the *gubernaculum dentis.* Most frequently there is, opposite the bottom of the follicle, one or more papillæ which, in some cases, adhere by their whole length to one of the lateral walls of the follicular sac, and the free extremities of which cross those of the dentine papillæ, or are buried in a kind of cup on the summit of the latter appendages (C). These are covered by the membrane of cylindrical cells mentioned above (D).

Fig. 228.



THEORETICAL SECTION OF THE DENTAL SAC OF A PERMANENT INCISOR IN THE HORSE.

A, Proper membrane of the sac; B, dental pulp; C, papilla of the external cavity (*pit*) of the tooth, a dependency of the enamel membrane; D, epithelial layer of the dentine membrane; E, cylindrical cells of the enamel membrane; F, dentine; G, enamel. The secretion of the cement is not supposed to have commenced.

With regard to the enamel organ, its internal face also presents a layer of cylindrical cells.

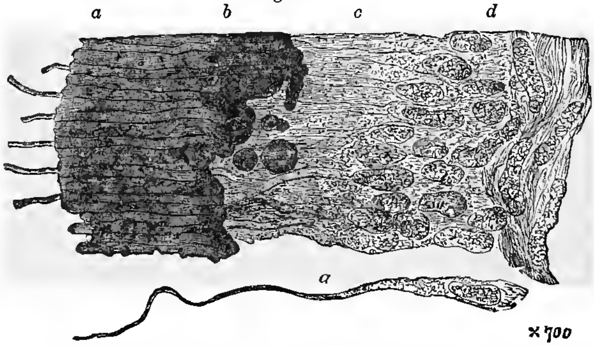
It is in the interval between these two papillary systems that the dental substance is deposited as in a mould, consequent on a process of secretion and transformation, the mechanism and progress of which are somewhat complicated. The *dentine* is produced by the metamorphosis of the superficial cells of the *dental germ.* These cells send out ramifying prolongations which constitute the tubuli of the dentine, and those of the middle layer secrete an intertubular amorphous substance, in which the earthy salts are deposited from without inwards. The *enamel* is deposited on the dentine, and results from the transformation of the cylindrical cells of the germ into enamel prisms. The *cement* is, in its turn, deposited either on the enamel or the dentine after their formation, and is produced, like the bony tissue, by the internal face of this (periodontal) sac, which has become alveolar periosteum.

When formed by the process above indicated, the tooth pierces its follicle and appears in the interior of the mouth, after having traversed the table of the maxillary bones, if there is any, and the gingival membrane. (When the calcification of the different tissues of the tooth is sufficiently advanced to enable it to bear the pressure to which it will be afterwards subjected, its eruption takes place, the tooth making its way through the gum. The gum is absorbed by the pressure of the crown of the tooth against it, which is itself pressed up by the increasing size of the fang. Concurrent with this, the septa between the dental sacs, at first fibrous in structure, soon ossify, and constitute the alveoli; these firmly embrace the necks of the teeth, and afford them a solid basis of support.) Though it has so far become established in its functions, the process of growth in the tooth has not yet ceased. The pulp lodged in the internal dental cavity, and charged with the formation of the ivory or dentine, continues its functions—incessantly depositing new layers on those which were originally secreted. The dental cavity gradually diminishes in extent; the papilla becomes atrophied, and finishes by disappearing altogether at a period of life more or less advanced, according to the kind of teeth and species of the animal.

In considering the entire dental apparatus, with regard to its development, very interesting differences are remarked in the progress and period of evolution —differences which have been made available for ascertaining the age of animals, but the details of which would be out of place here. It may only be noted that all animals have two successive dentitions: the first, composed of a certain number of teeth designated the *caducous* (*temporary*, *deciduous*, or *milk-teeth*—*caduques*, decaying or frail), because they are soon shed and give place to others which are stronger and more solid (and also because they appear while the animal is yet sucking); the second, comprising the latter, are named *replacing teeth*, with new, non-deciduous teeth which are not replaced, and are therefore named *persistent* teeth. (The *replacing* and *persistent teeth* are generally included by us in the term *permanent*.)

The teeth of Solipeds are gradually pushed from their alveoli as they grow;

Fig. 229.



THIN SECTION OF THE INNER PORTION OF THE DENTINE AND OF THE SURFACE OF THE PULP OF AN INCISOR TOOTH.

a, Portion in which calcification is complete, showing separate globular masses at the line of junction with the uncalcified substance, *b*; at *c* are seen oval masses of germinal matter (cells), with formed material on their outer surface; *d*, terminal portions of nerve-fibres.

and from this circumstance results deformity and thinning of the maxillæ in the regions which lodge the roots of the teeth.

B. Teeth of Solipeds.—The dentition of adult Solipeds is composed of from 36 to 40 teeth, thus distributed in each jaw: male, 6 incisors, 2 canines, 12 molars; female, 6 incisors, 12 molars.[1] With regard to the first dentition, it comprises the incisors and three anterior molars only, the canine teeth and three posterior molars being persistent.

The latter teeth—those of the second dentition—offer in their development a common, but very remarkable character, rarely met with in the other animals. They are pushed up from the alveoli during the entire life of the animal, to

([1] This is the number of persistent teeth given by all veterinary authorities, as well as by Professor Owen. Huxley, however, gives the typical number in the adult horse as forty-four. The first premolar is supposed to be a persistent, and not a deciduous tooth, as it has no successor.)

replace the surfaces worn off by friction; so that the crown is formed successively by the various portions of the fang, each of which issues in its turn from the alveolar cavity.

Incisors.—These are so named because they serve, particularly in the Herbivora, for the incision (*incido*, to cut) of the food. They are arranged in the segment of a circle, at the extremity of the jaw, and are distinguished by the names of *middle* or *central*, *intermediate* or *lateral*, and *corner* teeth. The *pincers* are the two middle teeth, the *intermediates* the next, and the *corners* occupy the extremities of the incisive semicircle.

The general form of these teeth is that of a trifacial pyramid, presenting a curve with its concavity towards the mouth. The base of this pyramid, formed by the crown, is flattened before and behind; the summit, or extremity of the fang, is, on the contrary, depressed on both sides; the shaft of the pyramid offers, at different points of its height, a series of intermediate conformations which are utilized as characteristics of age, the continual pushing outwards of the teeth bringing each of them in succession to the frictional surface of the crown (Fig. 232, 1).

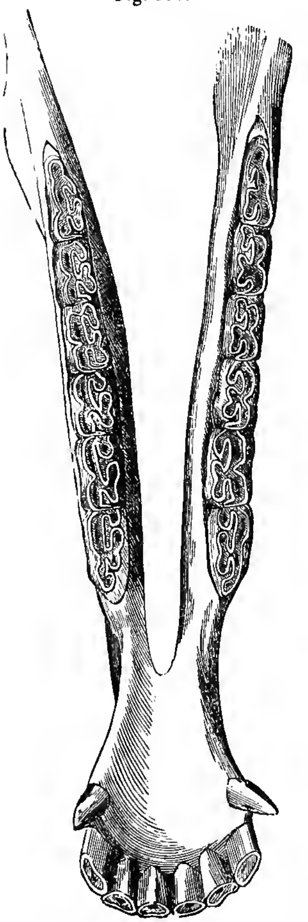
Examined in a young tooth which has completed its evolution, the *free portion* exhibits: an anterior face, indented by a slight longitudinal groove, which is prolonged to the root; a posterior face, rounded from side to side; two borders, of which the internal is always thicker than the external; lastly, the surface of friction (*table*). The latter does not exist in the tooth which has not been used; but in its stead are found two sharp margins circumscribing a cavity named the *external dental cavity* (or better, *infundibulum*). This cavity terminates in a conical *cul-de-sac*, which descends more or less deeply into the substance of the tooth. The margins are distinguished into anterior and posterior; the last, less elevated than the first, is cut by one or more notches which are always deepest in the corner teeth. It is by the wear of these margins that the surface of friction is formed, and in the centre of which the infundibulum persists during a certain period of time (Fig. 232, 2).

The *fang* is perforated by a single aperture, through which the pulp of the tooth penetrates into the internal cavity (Fig. 231, 3, *c*).

In the composition of the incisor teeth is found the three fundamental substances of the dental organ. The *dentine* (Figs. 231, 1; 232, 3) envelops, as has been shown, the pulp cavity. That which is deposited in this cavity after the complete evolution of the tooth, to replace the atrophied pulp, has always a yellower tint than the dentine of the first formation; it forms on the table of the tooth the mark designated by Girard the *dental star* (Fig. 232, 4, *c*). The *enamel* covers the dentine, not only on its free portion, but also on the roots of the incisors; it is not prolonged, however, to their extremities, though it is more on the anterior than the posterior face. It is doubled in the external dental cavity, lining it throughout (Figs. 231; 232, 4, *a*); and when the surface of friction is established, there can be perceived a ring of enamel surrounding that surface; and an internal ring circumscribing the infundibulum: the first circle forms what is called the *encircling enamel;* the second, the *central enamel* (Fig. 232, 4, *a*, *b*).

In the virgin tooth, the latter is continuous with the external enamel, and passes over the border which circumscribes the entrance to the infundibulum. The *cement* is applied over the enamel, like a protecting varnish; but it does not exhibit the same thickness everywhere: on the salient portions it is extremely thin, and does not even exist when the tooth has been submitted for some time to the friction arising from the contact of the aliment, the lips, and the tongue. It is more abundant in depressed situations, as in the longitudinal groove on the anterior face, and particularly at the bottom of the infundibulum. Nevertheless, the quantity accumulated in this *cul-de-sac* is not always the same; we have seen it sometimes almost null, and on the other hand we possess incisors unworn, or nearly so, in which the cavity is almost entirely filled by the crusta petrosa. We are not aware that, up to the present time, any account has been taken of these differences when calculating the progress of *wear;* but it may be imagined that they ought to influence in a sensible manner the period at which effacement of the external dental cavity takes place.

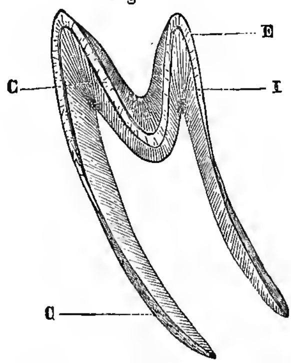
Fig. 230.



DENTITION OF THE INFERIOR JAW OF THE HORSE, THE TEETH SEEN ON THEIR TABLES.

Consult Fig. 38 for the dentition of the upper jaw.

Fig. 231.



SECTION OF THE INCISOR TOOTH OF A HORSE, SHOWING THE ARRANGEMENT OF ITS DIFFERENT SUBSTANCES.

I, Dentine; E, enamel; C, cement.

All the characteristics just indicated belong to the *deciduous teeth* (Fig. 232, 5), except that they are smaller than the permanent; that they are of a shining milky-white colour, due to the thinness or absence of the crusta petrosa; that they show at the point of union between the free portion and the root, a constriction named the *neck;* that their crown is finely striated, and not cannular, on the anterior face; that the external *cul-de-sac* (*infundibulum*) is shallow; and that they are not constantly pushed outwards from their cavities, their growth ceasing when they begin to be used. When the replacing teeth appear, they do so a little behind the temporary ones, the shedding of which they cause by gradually destroying their roots, these at last becoming only a long and very thin shell of dentine.

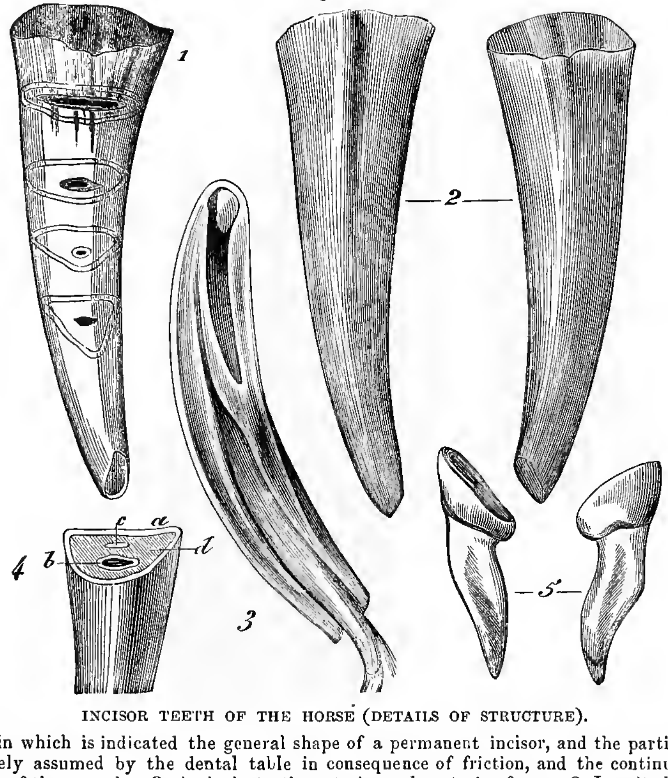
The follicle in which the incisor teeth are developed shows only two papillæ

—one for the secretion of the dentine, lodged in the internal cavity of the tooth, and hollowed into a cup-shape at its free extremity; the other contained in the external *cul-de-sac* (Fig. 228, A, B, C).

Tusks, Fangs, or Canine Teeth.[1]—"The tusks of Solipeds only exist in the male; it being quite exceptional to meet with them in the female, and even then they are rarely so strong as in the male.

"These teeth are four in number, and are placed one at each side of the jaws, a little behind the incisors, to which the lower canines are much nearer

Fig. 232.



INCISOR TEETH OF THE HORSE (DETAILS OF STRUCTURE).

1, A tooth in which is indicated the general shape of a permanent incisor, and the particular forms successively assumed by the dental table in consequence of friction, and the continued pushing outwards of these teeth. 2, A virgin tooth, anterior and posterior faces. 3, Longitudinal section of a virgin tooth, intended to show the internal conformation and structure. Not to complicate the figure, the external cement, and that accumulated in the infundibulum, has not been shown. 4, Transverse section for the same purpose: *a*, Encircling enamel; *b*, central enamel; *c*, dental star; *d*, dentine. 5, Deciduous tooth.

than the upper. Between them and the first molar there is left a considerable space, which constitutes the *bar* of the inferior jaw.

"The free portion of the tusk, slightly curved and thrown outwards, particularly in the lower jaw, offers two faces—an external and an internal—separated from one another by two sharp borders inclined to the inner side, and meeting in a point at the extremity of the tooth. The external face, slightly rounded, presents a series of fine striæ, longitudinal and parallel.

[1] The quotations included within inverted commas are from M Lecoq's *Traite de l'Extérieur du Cheval et des Principaux Animaux Domestiques.*

"The internal face has a conical eminence in its middle, whose point is directed towards that of the tooth, and is separated from each border by a deep groove.

"The fang of the tusk, more curved than the free portion, has internally a cavity analogous to that of the root of the incisors, and like it, this diminishes and finally disappears as it advances in age; but it is always relatively larger, because of the absence of the infundibulum in the canine teeth.

"The form we have described for the tusks, is that which they present while still young. As the Horse grows older they lose their whiteness, and become worn in an irregular manner, and this most frequently by the action of the bit or snaffle; for the difference in position of these teeth in the two jaws does not allow of friction between them.

"The canine teeth are not shed, and grow but once. Some veterinarians, and among them Forthomme and Rigot, have witnessed instances in which they were replaced; but the very rare exceptions cannot make us look upon these teeth as liable to be renewed. We must not, however, confound with these exceptional cases the shedding of a small spicula or point, which, in the majority of Horses, precedes the eruption of the real tusks.

"The structure of these teeth is much simpler than that of the incisors; consisting, as they do, of a central mass of dentine hollowed by the pulp cavity, and covered by an external layer of enamel, on which is deposited a little cement.

"The arrangement of the developing follicle is in harmony with the simplicity of structure of the tusks; at the bottom there is a simple and conical papilla for the internal cavity; on the inner wall, a double longitudinal ridge, on which are moulded the ridge and grooves on the internal face of the tooth."

Molar Teeth.—"The molars are twenty-four in number—six in each side of each jaw. There are also sometimes supplementary molars met with in front of the true ones, and which may be four in number; but these are small teeth, having but little resemblance to the others, are most frequently shed with the first deciduous molar, and are not replaced.

"Generally considered, the molar arches have not the same disposition in both jaws. Wider apart in the superior one, they form a slight curve, with the convexity outwards. In the inferior jaw, on the contrary, the two arches separate in the form of a V towards the back of the mouth. Instead of coming in contact by level surfaces, the molars meet by inclined planes, and in such a way that the internal border is higher than the external in the inferior molars, while the opposite is the case in the superior.

"Like the incisors, each molar presents for study a free and a fixed portion. The free portion, nearly square in the upper molars, longer than wide in the lower, shows at the external surface of the former two longitudinal grooves, the anterior of which is the deepest, and which are continued on the encased portion. This is not so with the inferior molars, which have but one narrow, and frequently an indistinct, groove.

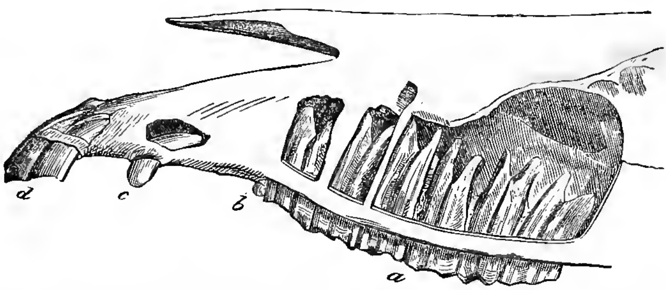
"The internal face in both jaws only shows one groove, and that but little marked; it is placed backwards in the upper molars, and is most apparent towards the root.

"The anterior and posterior faces are in contact with the corresponding faces of the adjoining molars, except at the extremities of the arches, where the isolated face is converted into a narrow border.

"With regard to the table of the tooth, it inclines, as we have already mentioned, outwards in the lower jaw, and inwards in the upper—a circumstance which prevents the lateral movements of the jaws taking place without separation of the incisors, which separation removes them from friction." In the virgin molar, this face is completely covered with enamel, and irregularly undulated. In it may be recognized the two infundibular openings, which are prolonged in the interior of the organ to the extremity of the root, and are almost entirely filled with cement at the period when the tooth has completed its evolution; they are only void before the secretion of this crusta petrosa. In the tooth which has been worn, this frictional surface assumes a particular aspect, which will be indicated with most advantage to the student by examining the structure of the molar.

"The root, if examined a short time after the eruption of the free portion, looks only like the shaft of the latter, without any appearance of fangs, and

Fig. 233.



PROFILE OF THE UPPER TEETH OF THE HORSE, MORE ESPECIALLY INTENDED TO SHOW THE MOLARS; THE FANGS HAVE BEEN EXPOSED.

a, Molar teeth; *b*, supplementary molar; *c*, tusk; *d*, incisors.

has internally a wide cavity. It is not until the tooth begins to be pushed from the alveolus and its crown to become worn, that its fangs are formed; these are at first hollow, and afterwards filled, as well as the cavity of the tooth, by the formation of a new quantity of dentine. From this time the fangs cease to grow; but the tooth, constantly projected beyond the alveolar cavity, allows the walls which enclose it to contract; so that, in extreme old age, it happens that the shaft, completely worn away—instead of the tooth—leaves several stumps formed by the fangs.

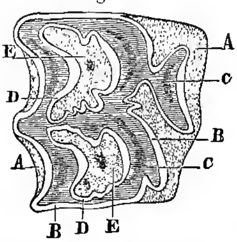
"The molars of the two jaws exhibit a variety of roots. In the molars terminating the arches, either above or below, or at the extremities of these, there are three; while the intermediate molars have four fangs in the upper jaw, and only two in the lower.

"The molars are separated from each other by their embedded portion, particularly at the two extremities of the arch; an arrangement which strengthens them by throwing the strain put upon the terminal teeth towards the middle of the line."

The structure of the molars resembles that of the incisors, though it is much more complicated. The internal cavity is extremely diverticulated, and enveloped by the *dentine*. The *enamel* is applied in a layer over it, and is doubled in its external *culs-de-sac* exactly as in the incisors. There is also on the table of the tooth which has been worn, an external covering of enamel, and two circles, or rather two irregular polygons, of central enamel circumscribing the two cavities. In the superior molars, these bands of enamel represent a Gothic B, having a small appendage on the loop nearest the entrance to the mouth. This figure is modified in the teeth of the lower jaw, the enamel of the infundibuli being continuous, on the inner side, with the external enamel. The *cement* is extremely abundant, and in the upper molars its total quantity nearly equals that of the dentine ; it accumulates in the *culs-de-sac* and on the external covering of enamel, where it partially fills up the flutings on the faces of the crown. Prolonged steeping of a molar tooth in hydrochloric acid, easily permits the isolation of these elements.

Owing to the arrangement above described, the section of an adult molar tooth, naturally represented by the surface of friction (Fig. 234), exhibits, outwardly, a layer of cement ; next, the external enamel ; between this and the central enamel, the dentine, always yellower, and sometimes even black in the middle ; lastly, the enamel bands of the infundibuli, and the crusta petrosa filling them. As these enamel bands are much harder than the other substances, they are worn more slowly, and stand out in relief on them. The table of the tooth has also, for this reason, the appearance of a veritable mill-stone, and is admirably disposed for the trituration of those fibrous substances on which the animal usually feeds.

Fig. 234.



TRANSVERSE SECTION OF A HORSE'S UPPER MOLAR TOOTH.

A, External cement ; B, external enamel ; C, dentine ; D, internal enamel ; E, internal crusta petrosa.

The follicle which develops these three elements of the molar tooth, has at the bottom an enormous papilla divided into several lobes, which lie together for their whole length ; lodged in the internal dental cavity, it gradually decreases, like the papilla in the other kinds of teeth, as the cavity becomes diminished by the formation of new dentine. Opposite to it are two long papillæ, which occupy the enamelled infundibuli.

"It was believed for a long time that the molars of Solipeds were all persistent teeth. This error, founded on the authority of Aristotle, was so deeply rooted, that although Ruini, towards the end of the sixteenth century, had discovered the existence of two temporary molars, Bourgelat did not believe it when he founded the French Veterinary Schools, and was only convinced when Tenon had proved by specimens, in 1770, that the first three in each arch are deciduous.

"The replacement of these twelve molars is not at all like what happens with the incisors. The molar of the adult grows immediately beneath the temporary one, and divides its two fangs into four, until its body is reduced to a simple plate and falls off, allowing the contracted summit of the permanent molar to appear ; and this grows up until it is soon on a level with the others in the row.

"The first replacing molar is always a little more elongated than that which it succeeds, and it most frequently expels at the same time the supplementary molar ; so that if forty-four teeth be developed in the male Horse, it is very rare that they are all present at the same time."

Ruttimeyer has remarked that the tables of the first three molars are shorter and wider in the **Ass** than in the Horse. The Gothic B the enamel forms is consequently compressed, and the appendage to the anterior loop is wider in the first than the second of these animals, and not so long. (Flower also observes that the loop of enamel above the B is either absent, or scarcely perceptible in the Asinine tribe.)

7. The Mouth in General.

We will now consider, as a whole, the cavity, the various parts of which have been studied in detail; and examine, successively, its *general arrangement*, *capacity*, and *mucous membrane*.

General disposition and capacity of the mouth.—The mouth, being elongated in the direction of the head, offers a great antero-posterior diameter, and two small diameters—one vertical, the other transverse. The first extends from the base of the epiglottis to the anterior opening of the mouth; the second, from the palate to the floor of the mouth; and the third, from one jaw to the other. When the jaws are in contact, the space included between these limits is divided into two regions: one central, the other peripheral. The first is circumscribed by the dental arches; the second is comprised between these arches on the one side, and the cheeks and inner aspect of the lips on the other. It may therefore be remarked, that the capacity of the mouth is almost null in these regions. The cheeks and lips, in reality, lie almost exactly against the alveolar arches, and the tongue, in contact with the palate by its superior surface, almost entirely fills the central region. If the jaws separate from one another, and the cheeks recede from the dental arches, the cavity of the mouth becomes enlarged in proportion as these movements are extensive. It must be remembered that the separation of the jaws is effected in an angular manner, and that the dilatation produced in the mouth by this movement is greater before than behind, the opening of the angle comprised between the two jaws being directed towards the entrance to the cavity.

Mucous membrane.—The walls of the buccal cavity are covered by a tegumentary membrane, which we have hitherto only examined in parts in the different regions it covers; but which, it is to be noted, forms here a single and continuous layer—the *mucous membrane of the mouth.*

This membrane is continuous with the external skin around the margin of the buccal opening; from this point into the interior of the cavity, it extends at first over the internal surface of the lips, then is prolonged backwards on the cheeks as far as the posterior pillars of the tongue. If it is examined above and below, to the bottom of the groove at the junction of the lips and cheeks, it is seen to cover the maxillary bones and envelop the base of the teeth, where it constitutes the *gums*. From the superior dental arch, it extends over the palatine arch and the soft palate. And from the inferior arch, it descends to the floor of the mouth, and is reflected over the tongue to form a covering for that organ. At the isthmus of the fauces it is continuous with the pharyngeal mucous membrane.

The organization of the mucous membrane of the mouth is perfectly in harmony with the digestive acts performed in that cavity. It is there where the alimentary substances, which are sometimes very hard, very resisting, and covered with asperities, are crushed; and to escape inevitable injury, this membrane is protected by a very thick epithelium in those places which are particularly exposed to the contact of these substances—such as the upper surface of the tongue, the palate, and the cheeks; even the corium, or sub-epidermic layer, is also greatly thickened. But nature has not made this provision for the parts which are removed from the direct contact of alimentary matters—as, for example, on the lateral aspects of the tongue, where the buccal membrane is delicately organized.

This membrane also shows, in its lingual portion, small organs for the perception of savours, which is one of the most important preparatory acts of the digestive functions; as the sensation resulting from this appreciation constitutes an excitant to the desire for food, and also informs the animal of the good or bad properties of the substances introduced into the mouth.

Differential Characters in the Mouth of the other Animals

That the different regions of the mouth in the domesticated animals should offer some diversities, will be readily conceived, as all are not submitted to the same *régime*, nor do they all live in the same manner.

Ruminants. 1. *Lips*.—The lips of the **Ox** are remarkably thick and rigid, and possessed of little mobility, notwithstanding the great development of the muscles that move them; so that they only concur indirectly in the prehension of food, the tongue being charged with the largest share in this important task. The upper lip offers, in the middle of its external surface, a large patch destitute of hair, variously coloured in different animals, always humid in health, covered by small depressed eminences, and perforated by minute apertures, through which the secretion of numerous thick, yellow, subcutaneous glandules passes to the surface. This space, situated between the two nostrils, constitutes the *muffle*. (Around the muffle are sometimes a few hairs of the nature of tentaculæ.)

In the **Camel, Sheep,** and **Goat,** the lips are thin and very mobile, and take an active part in the prehension of food. The upper lip does not show any muffle, and is divided into two portions by a median groove. In the Camel and Sheep, this groove is in reality a fissure; so that each half of the lip can be readily moved independently of the other. (The upper lip is covered with hair in these animals. The **Goat** has a long tuft of hair appended to its lower lip, the *beard*.)

2. *Cheeks*.—On the inner surface of the cheeks in the **Ox, Camel, Sheep,** and **Goat,** from the commissure of the lips to the first molar tooth, is a multitude of long, thick, conical papillæ directed backwards. Beyond, there are only small round elevations and a single row of large papillæ similar to the preceding, in a line with the upper molars. In the **Sheep** the mucous membrane is sometimes spotted black; in the **Camel** it is uniformly black.

3. *Palate*.—In the **Ox,** the palate is most extensive. Its posterior third is quite smooth, and the transverse ridges (*bars*) only occupy the anterior two-thirds. (They are usually sixteen in number.) They are not curved, but are cut into notches on their summit, which is inclined backwards. In the **Sheep** and **Goat,** as also in the **Ox,** is remarked, in front and in the middle, near the pad that replaces the upper incisor teeth, a kind of T, the stem of which is directed forwards, and at the extremity of its branches is a very narrow aperture, the buccal opening of *Jacobson's canal* (see *the Nasal Cavities* for a description of this canal).

On the palate of the **Camel** is a small salient crest that occupies the anterior two-thirds of the middle line, and on each side are traces of transverse furrows, which are rather large tubercles a little elongated from side to side.

4. *Tongue*.—The tongue of the **Ox** is distinguished by the enormous development of the muscles composing it. It is garnished with conical papillæ which have a horny sheath, and their summits, inclining backwards, give the tongue a very rough feel. In this animal it serves for the prehension of food; its mobility is very great, and it can be carried into the nostrils with ease. (The body of the organ is rounder, and the point finer, than in the Horse. The calyciform papillæ are spread over the whole of its dorsal surface; and at the root, on the middle line, is a somewhat deep groove.)

The tongue of the **Sheep, Camel,** and **Goat** is smaller, proportionally, than that of Solipeds.

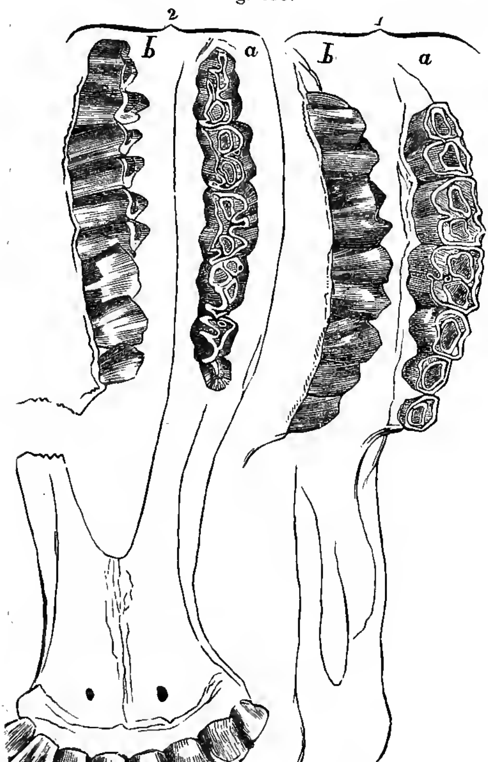
That of the Camel has an extremely rich papillary development. On the borders of the upper surface of the free portion are about half a dozen calyciform papillæ, more or less large, but some of them have a greater diameter than Morgagni's foramen. On the posterior half of the same part are foliated papillæ, which are less numerous and smaller as they proceed backwards. On the sides are small perforated prolongations analogous to the barbs of Wharton's ducts.

5. *Soft Palate*.—It may be said, in a general manner, that the palatine prolongation is shorter than in Solipeds. (The isthmus of the fauces is wider, however, and the amygdalæ,

very developed, are situated in the two large depressions formed on the sides of the soft palate by the folding of the mucous membrane.)

In the **Camel**, however, the soft palate is very developed, and the channel between the mouth and pharynx narrow and long. The anterior pillars ascend on the corresponding face of the curtain, which has a pyramidal, soft, relaxed appendage, granular on the surface, very movable, and with its base forwards; on each side of its summit, this appendage has two prolongations curving outwards, and below them a small sinus or diverticulum; on the borders

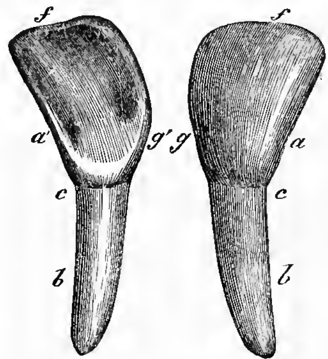
Fig. 235.



THE TEETH OF THE OX.

1, Upper jaw, with *a*, the friction surface, and *b*, the external surface; 2, Lower jaw, with *a*, the dental tables, and *b*, the external face.

Fig. 236.



OX'S INCISOR TOOTH.

a, Free portion, external face, outer border; *a'*, *ibid.*, internal face, outer border; *b*, root; *c*, neck; *f*, anterior border; *g*, *g'*, inner border.

are racemose glands, which raise the mucous membrane. The latter is of a dark colour, like the cheeks and palate.

6. *Teeth.*—The teeth of the **Ox** are thirty-two in number, twenty-four of which are molars, arranged as in the Horse, and eight incisors belonging to the lower jaw. The latter are replaced in the upper jaw by a thick cartilaginous pad, covered by the mucous membrane of the mouth; this pad forms the gum, and furnishes a bearing for the incisors of the lower jaw. Sometimes, as in the Horse, there are found supplementary molars, which, if four in number, will make up the whole to thirty-six; though they are never all present at one time as the supplementary ones are shed before the molar dentition is completed.

The composition of the Ox's teeth is the same as those of the Horse, the only difference being in the arrangement of the several substances.

Incisors.—The incisors, eight in number, are placed *en clavier* (like a key-board) at the extremity of the kind of rounded shoulder-bone by which the maxillary bone terminates, forming around this point a perfect circle when they have acquired their full development.

Instead of being fixed in the alveoli, as in Solipeds, they possess a certain degree of mobility, sometimes mistaken for a diseased condition; this is necessary, in order to prevent their wounding the cartilaginous pad of the upper jaw against which they press. They are divided, according to their position, into two *centrals*, two *first laterals*, two *second laterals*, and two *corner* incisors.

Each incisor offers for consideration two parts: one free, the other encased—the root, and separated by a very marked constriction—the neck. This arrangement gives to the tooth the form of a shovel, the root representing the handle (Fig. 236).

The free portion, flattened above and below, and thinnest and widest towards its anterior extremity, presents two faces—an inferior or external, the other superior or internal, with three borders, an anterior and two lateral.

The external face, slightly convex, and milk-white in colour, is covered with fine, undulating, longitudinal striæ, which disappear with age, and leave the surface beautifully polished (Fig. 236, *a*).

The internal face, flatter than the preceding, presents in its middle a slight conical eminence, whose base widens and is terminated near the free extremity of the tooth, while its sides are circumscribed towards each border by a well-defined groove (Fig. 236, *a'*).

The two lateral borders (the internal slightly convex in its length, the external slightly concave in the same direction) make the free portion appear as if thrown outwards. The anterior border is sharp, and slightly convex from one side to the other; it is the first part of the tooth destroyed by wear.

The root is rounded, slightly conical, and implanted in an alveolus of the same form; in youth, it shows at its extremity an opening communicating with an internal cavity analogous to that in the teeth of Solipeds, and prolonged into the interior of the free portion (Fig. 236, *b*).

In the virgin tooth, the enamel forms around the free portion a continuous layer, thinnest on the internal surface, and extending very scantily over a part of the root.

The dentine forms the remainder of the organ, and the (pulp) cavity, which is originally a large space of the same form as the tooth, is filled, as the animal grows old, by new dentine, which, as in the Horse, has a yellower tint than the primitive ivory.

When the cavity is completely filled, the tooth ceases to grow, and is not pushed beyond the alveolus during wear, like the teeth of the Horse.

The incisor tooth has scarcely arrived at its perfect development, before it begins to be worn. Its horizontal position, and its coming in contact with the pad on the upper jaw, exposes the anterior border and superior face to friction, and consequent wear from before to behind. The wear, therefore, chiefly affects this upper face, which really forms the table of the tooth, and which Girard designates the *avale.* When use has worn away the conical eminence and the grooves bordering it, the tooth is *levelled.*

As wear goes on, there appears at first, and at the extremity of the tooth, a yellow band, which is the dentine denuded of its enamel; and later, in this dentine a yellower transverse band shows itself. With increase of wear, this contracts, then widens, and finishes by forming a mark nearly square, and then round, which is nothing else than the recently formed dentine that fills the pulp cavity of the tooth. It is a veritable dental star, analogous to that in the Horse's tooth, and varying in form according to the incisor in which it appears.

In proportion as the teeth are used, they seem to separate from one another, although they still remain in the same places. This is because these teeth, in youth, only touched each other by their extremities, and as they became worn they decreased in width, and were necessarily separated to an extent varying with their degree of wear.

Finally, when the tooth has reached its last stage of wear, there only remains the root, the upper portion of which, becoming apparent by the retreat of the gum, stands as a yellow stump—very distant from those which form with it the remains of the incisive arch.

The first incisors (or *milk-teeth*) of the Ox, like those of the Horse, are all deciduous, and differ from those which replace them by their smaller volume, less width, the transparency of their enamel, and their being more curved outwards. Their roots are much shorter, and are destroyed by the succeeding teeth. The two temporary centrals are always separated by a marked interval, depending on the thickness of the fibro-cartilage in the maxillary symphysis during youth.

Molars.—As in Solipeds, the molars are six in each side of the jaws, but they are much smaller, and form a much shorter arch. Their reciprocal volume is far from being as uniform as in the Horse, but goes on augmenting from the first to the sixth; and to such a degree, that the space occupied by the three anterior molars is only about one-half of that required for the three posterior ones; the last molar alone occupies nearly four times as much space, lengthwise, as the first.

Their wearing surface, constructed on the same system as that of the Horse's molars, present eminences a little more acute.

The arrangement of their three constituents is in principle the same as in the latter animal.

As in the Horse, the three front molars are deciduous.

The teeth of the **Sheep** and **Goat** are, like those of the Ox, thirty-two in number, divided into eight incisors and twenty-four molars, to which are sometimes added supplementary molars.

The *incisors* of the *smaller Ruminants* are not disposed like a key-board, as in the Ox, but stand up to form a grip, resting against the pad on the upper jaw much more by their extremity than by their inner surface.

They are, besides, narrow, have scarcely any neck, and are fixed more solidly in the alveoli (Fig. 237).

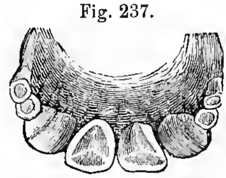
Their external face is white and polished, and is encased towards the gum in a kind of black cement.

The internal face has two wide, longitudinal grooves, separated towards the middle of the table by a simple ridge, which replaces the conical eminence of the Ox's incisor. These grooves are nearly always lined with the black cement-like substance.

The incisors of the **Sheep** are, like the Ox's, distinguished into temporary and replacing teeth; the first are known from the others by their smallness, and particularly by their narrowness.

The wear of the incisors in the **Sheep**, from their position, ought to take place nearer the anterior border than in the Ox; the dental star is observed earlier, and always forms a narrower line from before to behind.

Fig. 237.



INCISOR TEETH OF A SHEEP TWO YEARS OLD.

The second laterals and the corner incisors have not yet been replaced.

The absence of a neck in these teeth is the reason why they never appear to separate with wear, as has been remarked in those of the Ox.

The *molars* have the greatest resemblance, in their general form and relative proportions, to those of the Ox.

The teeth of the adult **Camel** are thirty-four in number—six incisors in the lower maxilla, ten molars, and six teeth resembling canines, two of which are fixed in the premaxilla. In the young animal, the *incisors*—the free border of which is sharp as in the other Ruminants—are much inclined on the maxillary border, but become erect as the creature grows older, so as to resemble those of the Horse.

The *canines* of the lower jaw are strong and pointed; among those of the upper jaw, the laterals only are greatly developed, and some authorities regard them as premolars.

The proper *molar* teeth show the general arrangement and organization of the Ox's teeth. They are covered by a dark cementum (Fig. 45).

PIG 1. *Lips.*—In this animal the lips are widely cleft. The lower is pointed and little developed; the upper is confounded with the *snout*, which will be described with the nostrils. (The upper lip has little mobility.)

2. *Cheeks.*—These are small and thin, and the mucous membrane smooth.

3. *Palate.*—Narrow and elongated, it is disposed as in the Horse. In front is seen the orifices of Jacobson's canals. (The transverse ridges are twenty to twenty-two in number, the anterior being larger than the posterior, and their free borders are united.)

4. *Tongue.* 5. *Soft Palate.*—These two organs are the same as in the smaller Ruminants, except that the filiform papillæ are perhaps less developed. (The isthmus of the fauces is circular, and the posterior pillars are confounded with the mucous membrane at the upper part of the œsophagus. Its anterior surface has several conical eminences in the middle, and the amygdalæ are little rounded elevations.)

6. *Teeth.*—The **Pig** has forty-four teeth, which are divided into twelve incisors, four canines, and twenty-eight molars (Fig. 238).

The incisors, six in each jaw, exhibit very remarkable differences between each other. The centrals and laterals of the upper jaw offer, by their form and the cavity they show on their table, some analogy to those of the Horse. In the lower jaw, these teeth are straight, directed forwards, and bear some resemblance to the incisors of rodent animals. The corner incisors of both jaws are isolated between the lateral and canine teeth, and are not nearly so voluminous as the other incisors.

The tusks are very developed, particularly in the male, and cross each other during the life of the animal; they project from the mouth, and form a very dangerous weapon in the wild boar. The primary canines are deciduous, like the incisors.

The *molars*, seven in each row, increase in volume from the first to the last, which is very strong. Their tables hold a middle place, with regard to arrangement, between that of the Carnivora and Herbivora.

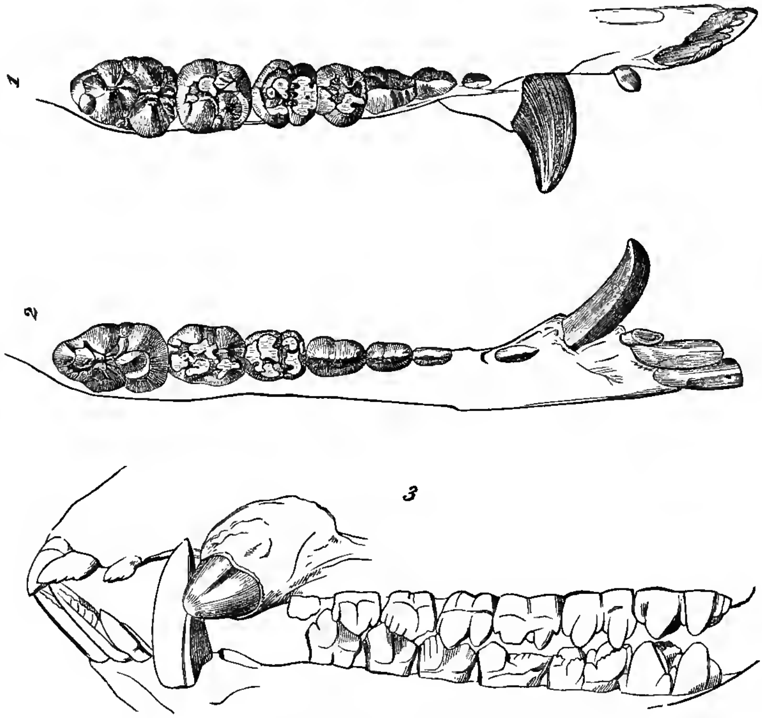
CARNIVORA. 1. *Lips.*—The Carnivora, like the Pig, do not use their lips to grasp their food, and these are therefore thin, though movable. The upper lip of the **Dog** has a groove in the middle line, and it covers the lower lip more or less at the sides according to the breed. The lower lip is always scalloped on its free border near the commissures, which are very high.

In the **Cat**, the hairy tentaculæ are collected on the upper lip into two long lateral tufts, the *moustaches;* they are very sensitive and movable.

2. *Cheeks.* 3. *Palate.*—The cheeks resemble those of the Pig; the palate that of small Ruminants. The mucous membrane is often stained by patches of pigment, especially on the palate. (The latter is frequently quite black. The number of ridges on the palate varies from seven to nine. Jacobson's canal opens behind the incisors.)

4. *Tongue.*—This is thin and very movable. The papillæ on its upper face vary somewhat in the *Cat* and *Dog.* In the **Cat,** the filiform papillæ on the anterior two-thirds of the tongue are covered by a very strong horny sheath, the point of which is directed backwards. In the **Dog** these papillæ are less developed, and there are observed, more particularly, a number of composite filiform papillæ, the divisions of which are very flexible. There also are found regularly disposed among these, white shining epithelial particles which correspond to small fungiform papillæ.

Fig. 238.



THE TEETH OF THE PIG.

1, Upper teeth, table surface; 2, lower teeth, table surface; 3, lateral view of the jaws.

At the base of the tongue of Carnivora, and within the anterior pillars of the soft palate, are two elongated bodies with rounded extremities and a nodulated slippery surface; these are true *amygdalæ*, formed by an agglomeration of closed follicles.

5. *Soft Palate.*—In the **Dog** and **Cat,** the soft palate is very short, and the isthmus of the fauces wide. Consequently, these creatures breathe easily by the mouth, and expel matters by it from the stomach during vomiting. At its free border, the soft palate shows a small prolongation, something like the uvula.

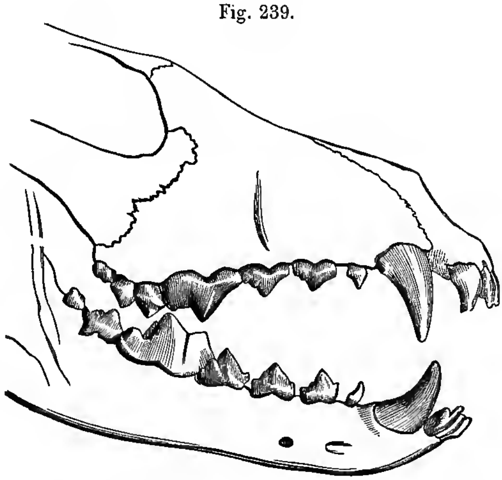
6. *Teeth.*—The teeth of the **Dog** are forty-two in number: twelve incisors, four canines, and twenty-six molars.

The *incisors*, six in each side of the jaws, are more developed in the superior than in the inferior maxilla, and are divided, as in the Horse, into centrals, laterals, and corner incisors; the last are much stronger than the preceding, and these again stronger than the pincers.

Their free part presents, in the virgin tooth, three tubercles: a middle, which is the strongest, and two lateral; these, together, are not unlike a trefoil or the upper part of a *fleur-de-lis*, especially those in the upper jaw. On the internal face is remarked a table or slope, somewhat resembling that of the Ox and Sheep, and separated from the root by a very distinct border, the extremities of which mark the lateral lobes. This table is of no advantage in ascertaining the age.

The root, very developed, flattened on both sides, and separated from the free portion by

Fig. 239.



GENERAL AND LATERAL VIEW OF THE DOG'S TEETH.

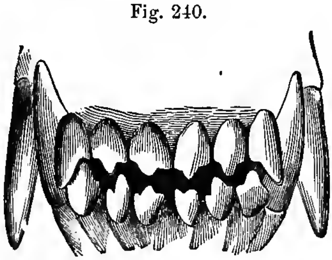
a well-defined neck, is solidly encased in a deep alveolus. Its internal cavity is very promptly obliterated.

When the tooth is submitted to wear, the middle lobe is the first to disappear; so that it no longer resembles a trefoil (Fig. 240).

The temporary incisors are much smaller and more pointed than the permanent ones; yet, like them, they show lateral lobes. At the period of their eruption these teeth are somewhat wide apart.

The fangs, or canine teeth, two in each jaw, are very strong, elongated organs, conical in form, curved backwards and outwards, and placed immediately after the incisors.

Fig. 240.



ANTERIOR VIEW OF THE INCISORS AND CANINE TEETH OF A YEAR-OLD DOG.

Fig. 241.

LATERAL AND GENERAL VIEW OF THE CAT'S TEETH.

The upper fangs are the thickest, and have a small space between them and the corner incisors, in which the inferior canines are lodged.

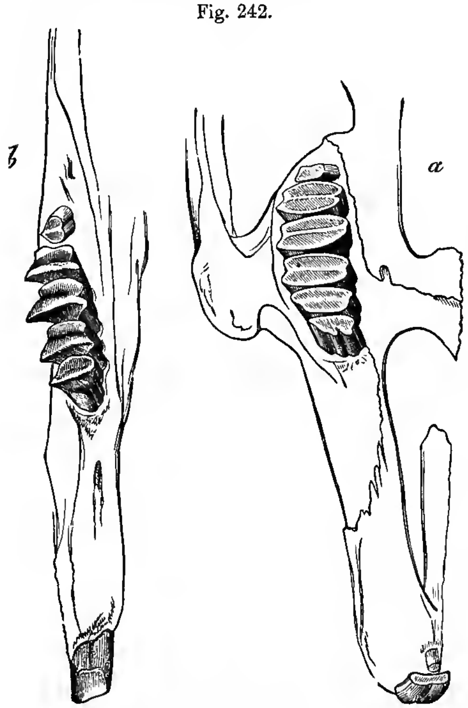
These teeth are deciduous, like the incisors, and are distinguished from the replacing ones by being thinner and more elongated.

They are worn more or less quickly, according to the kind of food the animal obtains, and are sometimes broken in fighting.

The *molars* are distributed in the two jaws, twelve being fixed in the upper and fourteen in the lower.[1] Nearly all of them are terminated by somewhat acute lobes, proper for tearing animal food. The strongest in each jaw is, for the upper, the first back-molar or fourth in the row, and in the lower, the fifth. All in front of these are deciduous.

After their complete eruption from the alveolar cavities, the **Dog's** teeth are no longer pushed outwards. They are remarkable for their brilliant whiteness, which they owe to the abscoce of cement on their covering of enamel.

Fig. 242.



DENTITION OF THE RABBIT: THE TEETH SEEN FROM THEIR TABLES.

a, Upper jaw; *b*, lower jaw.

The **Cat** has thirty teeth: twelve incisors, four tusks, and fourteen molars, eight of which are in the upper, and six in the lower jaw.

All these teeth are constructed on the same type as those of the Dog. The canines are deeply striated on their external surface, instead of being smooth.

Rabbit.—It may be noted that in the rabbit there are two incisors in the lower jaw, and four in the upper, two of which are placed behind the principal two. There are ten molars in the lower, and twelve in the upper, which are, in principle, as in the horse.

(The importance of a correct knowledge of the period of eruption, shedding, replacing, and general wear of the teeth of the domesticated animals, as a guide to their age, induces me to give the table on p. 431 (from Leyh), as indicating at a glance the age at which the teeth appear, are shed, and replaced in the different creatures.

Baumeister divides the successive evolutions in the wear of the tables of the horse's incisor teeth into four periods—from six years to extreme old age. The first, the transversely oval period, extends from six to twelve years; the round, from twelve to eighteen years; the triangular, from eighteen to twenty-four years, and the antero-posterior oval or triangular, from twenty-four years and upwards. Girard and other French authorities shorten these periods somewhat. The triangular period, for instance, only lasts from fourteen to seventeen years.)

Comparison of the Mouth of Man with that of Animals.

The shortness of *Man's* face influences the shape of the mouth; therefore it is proportionately shorter and wider than in the domesticated Mammals.

1. *Lips.*—The lips have a thick, free, everted border. They are lined by a rosy mucous membrane, which is insensibly continued inwards by the buccal membrane. The upper lip is limited by the nose and the naso-labial furrow; the lower is limited by the mento-labial groove. The first has in its middle the *subnasal furrow.* Their structure is analogous to those of animals.

2. *Cheeks.*—The cheeks are limited by the inferior border of the maxilla, the root of the ear, the prominence of the chin, and the naso-labial furrow. Between the skin and the mucous membrane, there is found—as in brutes—a glandular layer and muscles, chiefly the buccinator. An adipose ball is always found near the anterior border of the masseter.

[1] Toussaint has observed that, in breeds with short faces, the molars decrease in number, or are placed transversely, so as to find room in the maxillæ.

TEETH.	HORSE.		RUMINANTS.		PIG.		DOG.	
	Eruption.	Replacement.	Eruption.	Replacement.	Eruption.	Replacement.	Eruption.	Replacement.
I. Incisor Teeth.								
Centrals	Before, or some days after birth	$2\frac{1}{2}$ years	Before, or some days after birth	$1\frac{1}{2}$ years	3 to 4 months	$2\frac{1}{2}$ to 3 years	4 to 6 weeks	3 to 4 months.
First Laterals . .	4 to 6 weeks	$3\frac{1}{2}$ years	*Idem.*	$2\frac{1}{2}$ years	*Idem.*	*Idem.*	*Idem.*	*Idem.*
Second Laterals .	—	—	14 days	$3\frac{1}{2}$ years	—	—	—	—
Corners	6 to 9 months	$4\frac{1}{2}$ years	2 to 3 weeks	$4\frac{1}{2}$ years	Before, or some days after birth	6 months	*Idem.*	5 months.
II. Canine Teeth.								
Canine Teeth . .	6 months	4 to 5 years	—	—	*Idem.*	1 year	*Idem.*	5 to 6 months.
III. Molar Teeth.								
First	Before, or some days after birth	$2\frac{1}{2}$ years	Before, or some days after birth	$1\frac{1}{2}$ years	Before, or some days after birth	—	3 to 4 months	—
Second	*Idem.*	*Idem.*	*Idem.*	$2\frac{1}{2}$ years	*Idem.*	2 years	4 to 5 weeks	5 to 6 months.
Third	*Idem.*	$3\frac{1}{2}$ years	*Idem.*	$3\frac{1}{2}$ years	*Idem.*	2 years	*Idem.*	*Idem.*
Fourth	10 to 12 months	—	6 to 9 months	—	5 to 6 months	*Idem.*	*Idem.*	*Idem.*
Fifth	2 to $2\frac{1}{2}$ years	—	$2\frac{1}{2}$ years	—	1 year	—	4 to 5 months	—
Sixth	4 to 5 years	—	4 to 5 years	—	$1\frac{1}{2}$ to 2 years	—	5 to 6 months	—
Seventh	—	—	—	—	3 years	—	$5\frac{1}{2}$ to $6\frac{1}{2}$ months	—
NUMBER OF TEETH.								
Males	40		—		—		(Dog	42)
Females	36		32		44		(Cat	30)

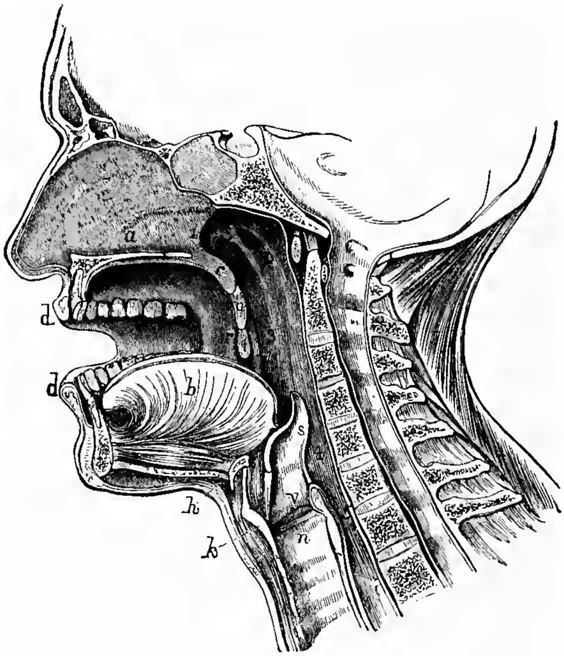
3. *Palate.*—It does not possess a vascular membrane, as in the Horse, and its mucous membrane shows a longitudinal and transverse furrow in its anterior two-thirds. It is pale and resisting.

4. *Tongue.*—This is thick, short, and broad; its base is almost vertical, and in the middle is a perpendicular, fibrous, and semilunar lamina—the *lingual septum*—which gives insertion to muscular fibres.

Anthropotomists distinguish intrinsic and extrinsic muscles. The first are: the lingualis superior and inferior, transversus, and longitudinalis. The second are, as in Solipeds, the stylo-glossus, genio-glossus, hyo-glossus, and pharyngo-glossus. There is also described a palato-glossus, which partly belongs to the soft palate.

The mucous membrane shows the different characters recognized in that of animals. That

Fig. 243.



MEDIAN ANTERO-POSTERIOR SECTION OF THE HUMAN FACE.

a, Septum of nose, with section of hard palate below it; *b*, tongue; *c*, section of soft palate; *d, d*, lips; *u*, uvula; *r*, anterior arch, or pillar of fauces; *i*, posterior arch; *t*, tonsil; *p*, pharynx; *h*, hyoid bone; *k*, thyroid cartilage; *n*, cricoid cartilage; *s*, epiglottis; *v*, glottis. 1, Posterior opening of nares; 3, isthmus faucium; 4, superior opening of larynx; 5, passages into œsophagus; 6, orifice of right Eustachian tube.

of the dorsal face is divided into two portions by two A-shaped rows of papillæ, the summit of which abuts on the deep mucous follicle named the *foramen cæcum*. The posterior portion presents depressions which correspond to the closed follicles, and the fungiform and calyciform papillæ; the anterior portion has a villous aspect, due to the great number of filiform papillæ coveringit.

5. *Soft Palate.*—In Man, the soft palate is short and divided into two portions: an *anterior*, horizontal, attached to the base of the tongue by the anterior pillars of the curtain; a *posterior*, movable and oblique, having a free portion, the *uvula*, and fixed to the lateral walls of the pharynx by the posterior pillars. The *amygdalæ*, or mass of closed follicles, are lodged in the triangular space between the anterior and posterior pillars. The fibrous structure is not present, unless the small expansion of the external tensor of the palate represents it. The muscles are the same as in animals, and, in addition, there are described two palato-glossal muscles, included between the mucous folds that form the anterior pillars. The palato-pharyngeus extends to the posterior nasal spine. The isthmus of the fauces is wider than in the Carnivora.

6. *Teeth.*—The teeth are thirty-two in number, sixteen in each jaw. They are distributed in the following manner: four incisors, two canines, two small molars (*bicuspidati*), and three large molars (*multi-cuspidati*).

The incisors, when viewed in profile or longitudinal section, have a wedge-shape, and their free border is more or less sharp. The canines are irregularly conical; the molars have a multiple fang, and the crown is studded with a variable number of tubercles: two on each small molar and four on the large. In youth, there are only twenty teeth, ten in each jaw.

The Salivary Glands.

The *salivary glands* are secretory organs annexed to the buccal cavity, into which they pour saliva—a recrementitious fluid that softens the food, favours its mastication and deglutition, and has a chemical action upon it after its arrival in the abdominal portion of the digestive tube.

Though very diversified in form, yet they present in their structure such common characters, that, to obviate recurrence to their organization when speaking of each gland, we will describe them here.

These glands are composed of a greyish-red or yellow spongy tissue, which is divided into small, rounded, or polyhedral masses, called *salivary lobules*. These extend in a layer beneath the adherent face of the mucous membrane, and remain isolated from each other, or are agglomerated in a body to form a single gland. In the latter case, they are united by close connective tissue, which covers them as a very thin enveloping membrane, and throws into the lobular interstices lamellar prolongations.

In studying the organization of one of these lobules, it will be observed that it is made up of many very small secondary lobules, or *acini*, which are themselves due to the agglomeration of minute elementary vesicles or follicles, the average diameter of which is from $\frac{1}{500}$ to $\frac{1}{1200}$ of an inch; these open into the little canal belonging to each of the secondary lobules, and which again joins those of the other acini of the primary lobule, to form a single duct.

The minute elementary vesicles or follicles—the *glandular culs-de-sac* (or *ultimate follicles*)—are more or less completely filled with delicate cells, transparent or slightly granular. They have for wall a thin amorphous membrane (*membrana propria*), against which, towards the bottom of the *acini*, and beneath the glandular epithelium, are cells having half-moon-like forms, a group of which constitutes a mass called the *crescent* (or *lanula*) *of Gianuzzi* (or *marginal cells*)—example, the submaxillary gland. (They are closely surrounded by a plexus of capillary blood-vessels.)

When the salivary lobules remain isolated, this canal—which is designated as *excretory*, because it carries from the lobule the saliva secreted within the elementary follicles—opens directly into the mouth. But when, on the contrary, they all unite and form a single gland, their excretory canals finally converge into one or more principal ducts, the termination of which, in every case, takes place in the same manner—by opening into the mouth from the summit of a more or less salient tubercle; this arrangement renders the introduction of particles of food into these excretory orifices somewhat difficult. The fibrous and elastic walls of these ducts are lined by cylindrical epithelium.

To the fundamental tissue just described must be added *arteries*, *veins*, and *lymphatics*, which convey the materials of secretion and nutrition; as well as the *nerves* which regulate the secretory and nutritive acts (excito-secretory and vaso-motor nerves). According to many histologists, the excito-secretory nerves remain between the acini, but others (Pflüger, Gianuzzi, Paladino) assert that they traverse the walls of the *culs-de-sac* and come into direct relations with the gland-cells.

The most voluminous of these glands—or those which comprise a very great number of agglomerated lobules—will be first noticed. They are the *parotid, maxillary, sublingual,* and *molar glands,* which are all pairs, and are placed in proximity to the mouth, when they do not lie immediately beneath the adherent face of its mucous membrane. Secondly, the less important glands—those which are spread in layers under that membrane, and including the *labial, lingual,* and *staphyline glands*—will be examined.

1. Parotid Gland (Figs. 168, 8; 247, 8).

Preparation.—This gland, with its excretory canal, is seen after the removal of the cervico-facial panniculus and parotido-auricularis muscle. By injecting Steno's duct and the facial artery and vein, the relations of these three vessels will be better seen at the maxillary fissure.

The *parotid gland* is situated in the space included between the posterior border of the inferior maxilla and the transverse process of the atlas. It is elongated from above to below, flattened on both sides, and divided into two faces, two borders, and two extremities.

Fig. 244.

LOBULE OF PAROTID GLAND, INJECTED WITH MERCURY, AND MAGNIFIED 50 DIAMETERS.

Fig. 245.

CAPILLARY NETWORK AROUND THE FOLLICLES OF THE PAROTID GLAND.

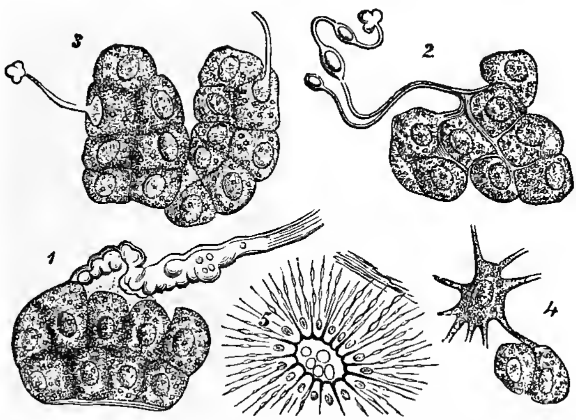
The *external face*, nearly plane, is hollowed in its inferior part into a longitudinal channel, which is sometimes transformed into a complete canal, and lodges the jugular vein after it has traversed the gland from below to its superficies. This *external face* responds to the parotido-auricularis muscle, the panniculus, the atloidean loop, a cervical ramification of the facial nerve, and the posterior auricular vein. The *internal face* is very uneven and moulded on the subjacent parts. It covers the guttural pouch, the mastoid insertion of the obliquus capitis superior, levator humeri, stylo-hyoideus, the tuberosity on the posterior border of the os hyoideus, the digastricus, the tendon of the sterno-maxillaris, and the submaxillary gland, which is separated from it by the thin cellulo-aponeurotic layer uniting the latter muscle to the levator humeri; also to the external carotid artery and its two terminal branches, the posterior auricularis, the muscles of the jaw, and, lastly, the facial nerve, which often passes through the substance of the gland.

The *anterior border* of the gland is intimately united to the posterior border of the maxilla; it is related to the temporo-maxillary articulation, the sub-zygomatic vessels and nerves, and the maxillo-muscular vessels. The *posterior* *border* is thicker than the preceding, and is separated from the transverse process of the atlas by the terminal aponeurosis of the levator humeri, to which it is only feebly adherent: it can also be easily separated from it, in order to raise the parotid and pass through the stylo-hyoideus muscle, in the operation of hyo-vertebrotomy.

The *superior extremity* is bifurcated, and embraces the base of the concha of the ear. The *inferior extremity* is comprised in the angle formed by the union of the jugular and glosso-facial veins.

Vessels and nerves of the parotid gland.—This gland receives its blood by a multitude of *arterial* branches from the large vessels it covers. Its *nerves* are very numerous, and are derived from the facial and inferior maxillary nerves. The excito-secretory nerve, says Moussu, is isolable on leaving the Gasserian ganglion; it is composed of four or five filaments which lie alongside the sub-zygomatic or inferior maxillary nerve for about a centimetre, then on the surface

Fig. 246.



MODES OF TERMINATION OF THE NERVES IN THE SALIVARY GLANDS.

1, 2, Branching of the nerves between the salivary cells; 3, termination of the nerve in the nucleus; 4, union of a ganglion cell with a salivary cell; 5, varicose nerve-fibres entering the cylindrical cells of the excretory ducts.

of the guttural pouch until it reaches the posterior border of the inferior maxilla and the internal maxillary vein, when it enters the gland. It is difficult to discover.

Small lymphatic glands are believed to have been seen in the substance of the parotid.

Excretory canal.—The parotid gland is provided with a single excretory canal—the *duct of Steno* or *Stenon*, so named from the anatomist who gave the first good description of it. It is detached from the anterior border of the gland, near its inferior extremity, where the eye may readily follow it between the lobules to the three or four principal branches from which it originates (Fig. 247). At first in contact with the terminal tendon of the sterno-maxillaris, it afterwards turns round the posterior border of the digastric muscle (stylo-maxillaris portion), advances into the submaxillary space, creeps over the pterygoid muscle, beneath the glosso-facial vein, and arrives at the maxillary fissure, into which it enters with the aforesaid vein and corresponding artery, but behind both. It then ascends externally along the anterior border of the masseter muscle, to the level of the inferior molars, when it passes beneath its two satellite vessels, obliquely crosses their direction, and pierces the cheek towards the third upper molar tooth, opening into the mouth by a large tubercle.

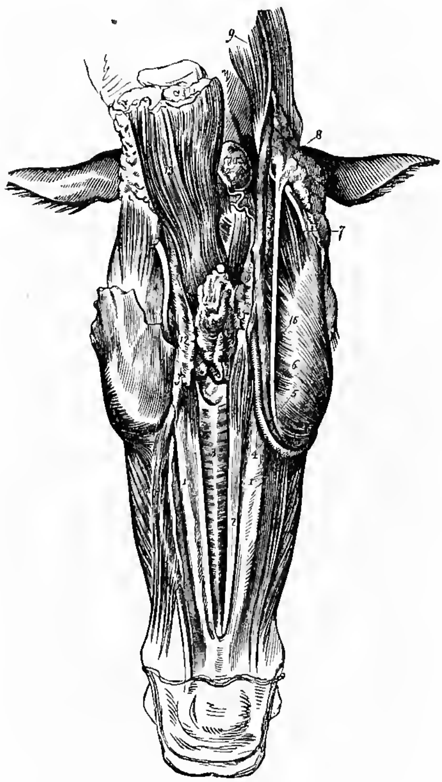
The parotid duct is composed of two membranes : the internal, mucous, with cylindrical epithelium ; and the external, made up of connective tissue, and circular and longitudinal elastic fibres.

2. Maxillary or Submaxillary Gland (Figs. 247, 248).

Preparation.—To expose this gland, as well as the sublingual, divide the inferior maxilla, as in preparing the muscles of the tongue for dissection (see p. 400).

This gland, smaller than the preceding, is situated in the submaxillary space, on the side of the larynx, and within the parotid gland.

Fig. 247.



INFERIOR ASPECT OF HEAD AND NECK.

1, Inferior border of lower jaw ; 2, genio-hyoideus ; 3, mylo-hyoideus ; 4, submaxillary artery ; 5, ditto vein ; 6, parotid duct ; 7, sterno-maxillaris tendon ; 8, parotid gland ; 9, sterno-maxillaris muscle ; 10, 11, 12, submaxillary glands ; 13, sterno-thyro-hyoideus and subscapulo-hyoideus muscles ; 14, thyroid gland ; 15, pterygoideus internus.

It is long and narrow, flattened on both sides, and describes a slight curve with the concavity turned upwards : a form which allows it to be studied, with regard to relations, on two faces, two borders, and two extremities.

By its *external face*, it responds to the internal pterygoid and digastricus muscles, the sterno-maxillaris tendon, and the cellulo-aponeurotic layer separating it from the parotid. Its internal face, applied to the side of the larynx, responds, superiorly, to the guttural pouch, to the carotid artery, and to the nerves which accompany that vessel in the upper part of the neck.

The *superior border*, thin and concave, is margined by the middle part of the digastricus. The *inferior*, thick and concave, is in contact with the glosso-facial vein.

The *posterior extremity* is maintained beneath the transverse process of the atlas, by an extremely loose and abundant connective tissue ; the *anterior* is insinuated between the internal pterygoid and the thyro-hyoideus muscle.

Vessels and nerves.—The blood is distributed to the maxillary gland by various small innominate *arteries*, like those of the parotid gland, and which are most frequently derived from the external carotid and the glosso-facial. The *nerves* are principally furnished by the *carotid plexus.*

Excretory canal.—*Wharton's duct*, as it is termed, is long and narrow; has very attenuated walls, and exists for nearly the whole length of the superior border of the gland (sometimes on its internal face), where it receives the ramifications from various lobules. At the anterior extremity of the organ it is free, and passes forward between the mylo-hyoideus and hyo-glossus muscles. After crossing, outwardly, the glosso-facial artery and great hypoglossal nerve, and, inwardly, the tendon of the digastricus and the lingual nerve, it passes between the great hyo-glossus muscle and the sublingual gland, lying closely to the inner side of the latter; thus it extends parallel to the lateral groove (or channel) of the lingual canal on the floor of the mouth. It finally arrives near

Fig. 248.

MAXILLARY AND SUBLINGUAL GLANDS.
R, Maxillary gland; S, Wharton's duct; T, sublingual gland.

the frænum of the tongue, but underneath the buccal membrane, and opens into the mouth by a small, but very salient, floating tubercle, situated a little in advance of the frænum, and vulgarly named the *barb* (*barbillon*).

The structure of Wharton's duct is identical with that of Steno, but its external tunic is extremely thin, and has not any circular elastic fibres.

3. Sublingual Gland (Fig. 248).

This is less in volume than the preceding, and is situated under the tongue, in the submaxillary space.

Elongated from before to behind, and very flat laterally, it has, like the submaxillary gland, two faces, two borders, and two extremities, the relations of which we will briefly indicate.

The *external face* is covered by the mylo-hyoideus muscle; the *internal* responds to Wharton's duct and the genio-glossus and great hyo-glossus muscles. The *upper border* projects beneath the mucous membrane on the floor of the mouth, where it forms the *sublingual ridge*; the *inferior*, thin and sharp, is comprised between the mylo-hyoideus and the genio-glossus muscles. The *two extremities* are thin and tapering; the *posterior* contains a branch of the lingual nerve; the *anterior* extends to the bottom of the angle formed by the union of the two branches of the inferior maxilla.

Vessels and nerves.—This gland possesses a special, but small *artery*—the *sublingual*. Its nerves come from the *lingual* nerve, and even from the *carotid plexus*.

Excretory canals.—These number fifteen or twenty, and are named the *ducts of Rivinius*. Flexuous and very slender, they are detached from the superior border or internal face of the gland, ascend perpendicularly, and open into the mouth on the sublingual crest or ridge, by a linear series of small orifices pierced, as usual, in the centre of a tubercle.

4. Molar Glands.

These are so named, because they are disposed parallel to the molar arches. There are two on each side.

The *superior molar gland*—the most considerable—appears as a narrow line of salivary lobules placed outside, and along the upper border of, the buccinator muscle. In its posterior part, where it is concealed beneath the masseter muscle, this gland is thicker and more compact than in front, where the few lobules which compose it scarcely come in contact with each other.

The *inferior molar gland*—less lobulated and voluminous, and not so wide as the preceding—is placed at the inferior border of the buccinator, immediately beneath the mucous membrane of the mouth, and near the point where it is reflected from the side of the cheek on to the inferior maxilla. It is bordered, for the whole of its extent, by the buccal nerve.

Both glands pour their secretion into the mouth by numerous salient orifices, which can be seen arranged in line on the buccal membrane, parallel to each molar arch.

It may be remarked that these glands establish a transition between the preceding and those yet to be mentioned. Their lobules are far from being so compact as the parotid or sublingual lobules; and they tend to separate from each other, to become more independent. Therefore it is that many writers regard them as distinct, and describe them as *superior* and *inferior molar glands*.

5. Labial, Lingual, and Staphyline Glands.

The lobules composing these glands are spread in layers, more or less thick, on the inner face of the mucous membrane, instead of being agglomerated in masses, as in the previous glands. Sometimes they are scattered, in consequence of their small number. In general, the excretory duct of each glandule opens independently into the mouth, without communicating with those of the neighbouring lobules.

Labial Glandulæ.—These are more abundant in the upper than in the lower lip, and pass beyond the commissures, to be spread for a short distance over the inner aspect of the cheeks. It is easy, in the living Horse, after turning up the lip and carefully wiping it, to see the salivary fluid secreted by these small organs escape from their excretory ducts.

Lingual Glandulæ.—They form a layer under the mucous membrane at the base of the tongue, and adhere very closely to the fibres of the small hyo-glossus muscle, and, laterally, are continuous with the layer which covers the external face of the amygdaloid mucous membrane. They are also found on the side of the tongue, above the superior border of the great hyo-glossus muscle; though these are few and scattered, and look as if embedded in the substance of that muscle.

Staphyline Glandulæ.—The thick layer these form under the anterior mucous covering of the soft palate, has been described with that organ. We have only to observe here, that it is continuous, laterally, with the glands at the base of the tongue, through the medium of the glandulæ of the amygdaloid cavity; and in such a manner, that the part of the mouth immediately in front of the isthmus of the fauces, and which might be justly considered as the isthmus itself, is enveloped in a complete glandular zone. In the dead body, we always find in this compartment a variable quantity of viscid fluid, which is certainly secreted in this zone. It is here, then, that the alimentary bolus is enveloped in the glutinous matters intended to favour its passage in the pharynx and œsophagus; and it is worthy of notice that the constricted canal in which this secretion is poured out in the living animal, immediately precedes the canal traversed by the bolus of food in the act of deglutition.

Differential Characters in the Salivary Glands of the other Animals.

The salivary system of the Herbivora is more extensive than that of the Omnivora, and especially the Carnivora.

Ruminants. 1. *Parotid gland.*—The parotid glands of the **Ox** are distinguished by their meagre development and red colour, which contrasts markedly with the pale yellow hue of the maxillary glands. Those of the **Camel** have the same characters, and they are broader than they are long. In that animal, as well as in the **Sheep** and **Goat**, Steno's duct passes through the masseter muscle. Moussu has seen the excito-motory nerve of the parotid, in the Ox, become detached from the buccal nerve beneath the masseter muscle, become inflected on the anterior border of that muscle, and pass backward and downward in the gland, following Steno's duct. In the Sheep, the same origin and course; consequently, the nerve passes on the surface of the masseter, along with Steno's duct. It is often formed by two parallel filaments, and is easily found and stimulated in order to produce the parotideal secretion. (In the **Ox**, this gland offers, at the upper part of its anterior border, a round lobe lying on the masseter. Steno's duct opens into the mouth at the fifth molar. It terminates in the **Sheep** and **Goat** at the fourth molar.)

2. *Maxillary gland.*—In the **Ox**, this gland is much thicker than in Solipeds, its volume being in inverse relation to that of the parotid. In its posterior moiety it enlarges into an oval lobe which, below the larynx, lies against that of the opposite side. Wharton's duct follows the same course as in the Horse; the papilla through which it opens is hard, resisting, and notched, and is lodged in an elliptical fossette near the incisors.

The maxillary gland of the **Camel** is slightly lobulated, and Wharton's duct does not open at the summit of the "barb," but at the base of the frænum linguæ by a kind of punched-out opening.

3. *Sublingual gland.*—In the **Ox**, **Sheep**, and **Goat**, this gland comprises two portions: a posterior, somewhat voluminous and lobulated, provided with a special excretory duct, which follows and opens near Wharton's duct (by the *ductus Bartholinianus*); and an anterior, pouring out its secretion by many canals, and representing the gland proper. This arrangement allows the saliva to be collected separately from this gland. In the **Camel**, this gland is very small, its lobules being also loosely agglomerated; it has only multiple ducts, as in the Horse.

4. *Molar glands.*—These are more developed in Ruminants than in Solipeds. The upper one is enlarged at its posterior extremity. Their nerves come from the buccal nerve.

Pig.—*The parotid gland* of this animal is little developed, as in Ruminants, and Steno's duct follows the posterior border of the lower jaw. (Leyh says that it is, proportionately, largely developed; that its upper end does not reach the concha of the ear, and that Steno's duct opens at the sixth molar.)

The *sublingual gland* is analogous in its disposition to that of the Ox. Cuvier, in his *Leçons d'Anatomie Comparée*, indicates this:—"The **Pig** has two sublingual glands. One, very long and narrow, accompanies, outwardly, the excretory canal of the submaxillary gland, from the angle of the jaw to the second sublingual. It is composed of small lobules of a pale red colour. Its excretory duct arises near the posterior third, and passes along with, but to the outside of, the submaxillary duct. It terminates near the orifice of the latter by a small opening; its diameter is equally small. The second sublingual gland is placed before the first; its form is square and flattened, and the lobes of which it is composed are larger and redder. It has from eight to ten excretory ducts." (In this animal the duct of Wharton does not open into the mouth by a papilla; consequently, there is no *barb.*)

Carnivora.—The parotid of the **Dog** and **Cat** is small, and Steno's duct always passes through the masseter. (It opens at the fourth molar in the Dog, and the third in the Cat.)

In the **Dog**, the *submaxillary* glands are larger than the parotids. "They even have in front, along Wharton's duct, a small accessory gland, with a distinct excretory canal opening into the same papilla as Wharton's." (Leyh states that the submaxillary duct does not project into the mouth.) The supplementary gland is absent in the **Cat**.

The *sublingual gland* is not present in the **Dog**; it is very small in the **Cat**, and carried further back than in the other animals. (Leyh describes a sublingual gland as present in the Carnivora, which is divided into two portions, as in the Pig: the anterior being formed of detached lobules that open into the mouth by several ducts; and the posterior, larger above than below, with two ducts, the smaller opening into Wharton's duct, and the larger a little in front of it.)

The *upper molar gland* of the **Dog**, scarcely noticeable for the greater part of its extent, forms posteriorly, under the zygomatic arch, near the eye, an independent lobe, remarkable for its large size and its single excretory duct. Duvernoy, who first described it, proposed to name it the *subzygomatic gland.* It is not present in the **Cat**. (This is doubtless the organ described by Leyh as the *orbital gland,* which, he says, is only found in the Dog; the superior molar gland, according to him, not existing in that animal. This orbital gland is external to the ocular muscles, has three or four excretory canals—the *ductus Nuckiani*—which converge into one duct that opens into the mouth above the last molar.)

The *labial, lingual,* and *staphyline glandulæ* are much less developed in the Carnivora than the Herbivora. This predominance of the salivary system in the latter is sufficiently accounted for, when we consider the hard, fibrous, and coriaceous food these animals live upon, and which must be ingested in large quantity, because of the small amount of nutrition it contains. For its mastication and deglutition, a great amount of saliva is absolutely necessary.

Rodents.—In the **Rabbit**, the *inferior molar gland* is very large. In addition to the salivary glands already described, this animal has a small gland outside the buccinator muscle, along the inferior maxilla, at the mental foramen.

Comparison of the Salivary Glands of Man with those of Animals.

As in animals, the *parotid* is the most voluminous of the salivary glands. Its tissue is reddish-grey and lobulated, the lobules adhering closely to each other. Its shape is irregular, and it is moulded to the excavation behind the angle of the jaw. Steno's duct passes across the masseter, and shows on its course some salivary lobules, forming what is named the *accessory parotid* (or *socia parotidis*); it opens opposite the third upper molar.

The *submaxillary gland* weighs about half an ounce. It is partly situated beneath the deep cervical fascia, and partly within the body of the lower jaw, between the mylo-hyoideus and hyo-glossus muscles. Its lobules are more loosely united than those of the parotid. *Wharton's duct* opens on the sides of the frænum linguæ by a small opening at the apex of a round papilla (*caruncula sublingualis*).

The *sublingual gland* is analogous to that of the Ox and Pig. There are, in fact, two sublinguals: an anterior about the size of an almond, and furnished with a single excretory canal—the *ductus Bartholini*, that terminates near Wharton's duct; the other, posterior, formed by several isolated lobules with multiple excretory ducts—the *ductus Riviniani.*

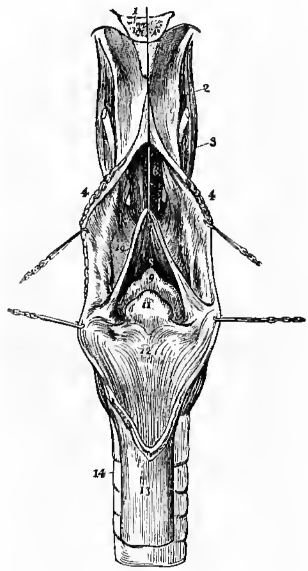
There are also labial, staphyline, and lingual glands; with, besides, near the frænum, a small conglomerate gland—the *gland of Nuhn*—which has a special duct.

The Pharynx (Figs. 249, 250, 251).

Preparation.—1. Study the general disposition and situation of this vestibule in the antero-posterior vertical section of the head (Fig. 250). 2. In order to examine the interior conveniently, the head should be separated from the neck, leaving attached to it a certain portion of the trachea and œsophagus; then by sawing across—either through or behind the temporo-maxillary articulations—all that portion of the cranium is removed, and the posterior parietes of the pharynx is exposed, and may be dissected to study the muscles (Fig. 251), or opened in the middle line to reach the interior of the cavity (Fig. 249). 3. The muscles should be dissected with those of the tongue, and in the same manner.

The *pharynx* is a membranous vestibule common to the digestive and air passages, and situated behind the soft palate, which separates it from the mouth; above, it is attached to the base of the cranium, and, below, to the laryngeal apparatus.

Fig. 249.



PHARYNGEAL AND LARYNGEAL REGION; THE POSTERIOR PART OF THE HEAD INCISED AND THROWN FORWARD.

1, Base of the cranium; 2, roof of the pharynx; 3, muscles of the cheek; 4, 4, walls of the pharynx; 6, posterior nares; 7, soft palate; 8, entrance to the mouth; 9, epiglottis; 10, posterior pillars of soft palate; 11, arytenoid cartilages; 12, opening of the œsophagus; 13, œsophagus; 14, trachea.

Form and internal disposition.—In consequence of the conformation of the soft palate, which, in the domesticated animals, and particularly in Solipeds, is prolonged to the base of the epiglottis, the pharynx forms a cylindro-conical cavity, elongated from before to behind, enclosed laterally and posteriorly by wide thin muscles, and with the soft palate for an anterior wall. Between the two Eustachian tubes, under the base of the cranium, the pharyngeal cavity presents a triangular diverticulum, the walls of which are only mucous membrane. This diverticulum is much deeper in the **Ass** than in the Horse.[1] At the two extremities of this cavity are openings which allow the pharynx to communicate with the other passages or cavities, which we will at once begin to study.

At the upper extremity of the large axis of the pharyngeal cavity, is to be remarked: 1. In front, the two posterior openings of the nasal cavities. 2. Behind, and directly opposite the preceding, the two pharyngeal openings of the Eustachian tubes, which are closed by a cartilaginous kind of clap-valve.[2]

At the inferior extremity of this axis is found: 1. In the centre, a vast gaping orifice projecting into the interior of the pharyngeal cavity, like a tap into a cask: this is the *entrance to the larynx*, the salient portions of which form, on the walls of the pharynx, two

[1] This *pharyngeal cæcum* was described for the first time by Verhsar of Utrecht.

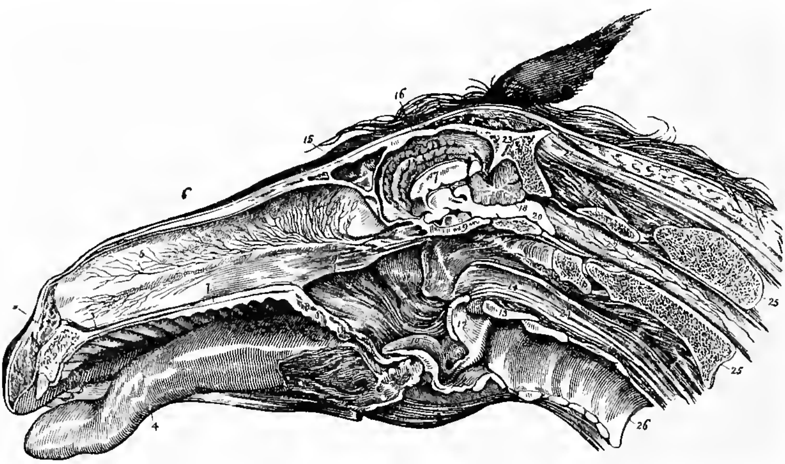
[2] This region corresponds to the posterior nares (*arrière fond*) of Man, a diverticulum which cannot be distinguished from the pharynx in the domesticated animals. Under the designation of the *posterior nares of the nasal fossæ*, it will be understood that we mean the posterior extremities of these cavities.

lateral channels, limited superiorly by the posterior pillars of the soft palate. 2. In front of, and beneath this, is the *isthmus of the fauces;* behind and above, the *œsophageal opening* at the bottom of an infundibulum, which may be considered as a special region of the pharynx.

These seven openings into the pharyngeal cavity give it the appearance of a cross road, into which abut different thoroughfares. It is necessary to note that the air and digestive passages intersect each other here; and in such a way that, during deglutition, the bolus of food passes over the entrance of the larynx to reach the œsophageal opening. This peculiarity is easily seen by referring to Fig. 250.

Relations.—Viewed externally, for the study of its connections, it will be found that the pharynx is related, posteriorly, to the guttural pouches, and guttural or retro-pharyngeal lymphatic glands; laterally, to the great cornu of the

Fig. 250.



MEDIAN LONGITUDINAL SECTION OF HEAD AND UPPER PART OF NECK.

1, Upper lip; 2, premaxilla; 3, hard palate; 4, tongue; 5, septum nasi; 6, nasal bone; 7, palatine bone; 8, soft palate; 9, pterygoid bone; 10, epiglottis; 11, entrance to Eustachian tube; 12, arytenoid cartilage; 13, cricoid cartilage; 14, œsophagus; 15, frontal bone and sinus; 16, cerebrum; 17, corpus callosum; 18, cerebellum; 19, sphenoid bone; 20, medulla oblongata; 21, cervical ligament; 22, spinal cord; 23, occipital bone; 24, 24, atlas; 25, 25, dentata; 26, trachea.

os hyoides, the internal pterygoid and stylo-hyoid muscles, the glosso-pharyngeal, great hypoglossal, and superior laryngeal nerves, and the glosso-facial artery.

STRUCTURE.—The walls of the pharynx are composed of a *mucous membrane,* external to which is a *fibrous* and a *muscular layer.*

1. *Mucous membrane.*—This membrane is covered, externally, by a thin layer of yellow elastic fibres, and is much more delicate and less protected by its epithelium than the buccal mucous membrane, of which it is a continuation; it is continuous with that of the œsophagus, the larynx, the nasal fossæ, and the Eustachian tubes.

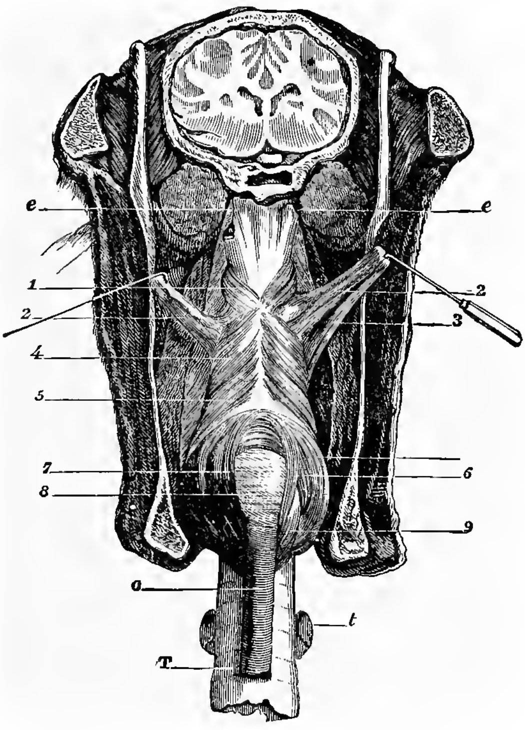
Its *epithelium* is stratified throughout; but it is thin and *ciliated* in the upper part, thicker and *tesselated* on the inferior moiety, which more particularly belongs to the digestive apparatus.

Everywhere there are *racemose glands,* though they are most numerous towards the roof of the pharynx. There are also some *follicular glands* beneath the mucous membrane, in the neighbourhood of the guttural opening, the nasal cavities, and the Eustachian tubes. Lorge has described a lymphoid gland, analogous to the pharyngeal amygdalæ described by Kölliker, at the bottom of the diverticulum between the Eustachian tubes.

2. *Fibrous layer.*—This is also named the *pharyngeal aponeurosis.* It commences at the base of the cranium, is first seen on the posterior face of the pharynx, then it passes beneath the muscular layer, where it gradually becomes thinner. It is attached inferiorly to the cartilages of the larynx, and to a fibrous cord that separates the pharynx from the œsophagus.

3. *Muscular layer.*—This is composed of six pairs of muscles, indicated in

Fig. 251.



PHARYNX OF THE HORSE (POSTERIOR VIEW).

T, Trachea; *t*, thyroid gland; o, œsophagus; *e*, *e*, Eustachian tubes, divided near their termination in the pharynx. 1, Pterygo-pharyngeus, or superior constrictor; 2, 2, stylo-pharyngeal muscles; 3, 3, great cornua of the os hyoideus; 4, hyo-pharyngeus, or middle constrictor; 5, 5, thyro-pharyngeus, or thyroid fasciculus of the inferior constrictor; 6, crico-œsophageus; 7, superior longitudinal œsophageal muscle; 8, origin of the œsophagus; 9, posterior crico-arytænoid muscle.

the following enumeration: the *palato-pharyngeus*, *pterygo-pharyngeus*, *hyo-pharyngeus*, *thyro-pharyngeus*, *crico-pharyngeus*, *stylo-pharyngeus*.

Palato-pharyngeus (*Pharyngo-staphylinus*).—This muscle, which has already been described as belonging to the soft palate, is prolonged backwards on the lateral wall of the pharynx, where its fibres are mixed with those of the pterygo-pharyngeus, and go to be attached to the superior border of the thyroid cartilage, by passing beneath the hyo-pharyngeus and thyro-pharyngeus muscles.

It therefore also belongs to the pharynx, and in contracting diminishes that cavity.

Pterygo-pharyngeus, OR SUPERIOR CONSTRICTOR (the *palato-pharyngeus* of Percivall).—This muscle is thin, wide, flat, and triangular. It arises from the pterygoid process, whence its fibres diverge, some posteriorly, others inwardly. The former mix with those of the palato-pharyngeus, and comport themselves like that muscle; and the latter are united, on the median line, with the analogous fibres of the opposite muscle, forming a kind of zone around the origin of the Eustachian tube. This muscle is covered, externally, by a layer of yellow elastic tissue, which is attached with it to the pterygoid bone; afterwards it is fixed to the superior border of the great cornu of the os hyoides, and is even prolonged on the external surface of the muscle it covers to the thyroid cartilage.

The elasticity of this fibrous layer plays a certain part in the movements of the hyo-laryngeal apparatus, in acting as a passive antagonist of its depressors.

This muscle is, and can only be, a perfect constrictor of the pharynx, as it diminishes the diameter of that cavity in every direction—the longitudinal diameter, by means of its posterior fibres, which draw the thyroid cartilage forward; and its transverse diameter, by the band thrown around the orifice of the Eustachian tubes (Figs. 220, 6; 251, 1; 252, 8).

Hyo-pharyngeus, OR MIDDLE CONSTRICTOR; **Thyro-pharyngeus,** OR FIRST MIDDLE CONSTRICTOR; AND **Crico-pharyngeus,** OR INFERIOR CONSTRICTOR.—The two last of these muscles only form one in Man—the *inferior constrictor* of the pharynx. They are three muscular bands which terminate above the pharynx, on a median fibrous fold, sometimes wide enough to look like a triangular aponeurosis. The first band arises from the cornu of the os hyoides; the second, from the external surface of the thyroid cartilage; the third, from the superficial face of the cricoid cartilage.

These are universally regarded as constrictors (Figs. 220, 7, 8, 9; 251, 4, 5, 5).

In attentively examining the crico-pharyngeus muscle of different authorities, two fasciculi are recognized, which can be distinguished by the direction of their fibres. The deep band passes to the origin of the œsophagus; it will be described, as well as the muscle hitherto named the arytæno-pharyngeus, when the œsophagus is referred to.

Stylo-pharyngeus.—A narrow band which descends from the inner surface of the styloid bone on the side of the pharynx, where it is confounded with the pterygo-pharyngeus. It passes beneath the hyo-thyroid and crico-pharyngeal muscles, and, spreading out like a fan, becomes attached to the upper border of the thyroid cartilage and mucous membrane of the pharynx, above the posterior pillar of the soft palate.

It narrows the longitudinal diameter, and it has been also regarded as a dilator; though the disposition of the parietes of the pharynx and the feeble volume of this muscle, scarcely allow it to play any efficacious part in the dilatation of that cavity. At most, it can only produce a very slight infundibulum where it is inserted. The real dilating agent of the pharyngeal cavity is the alimentary bolus, which is pushed into it by the action of the tongue and soft palate (Fig. 251, 2, 2).

It is not rare to find a second *stylo-pharyngeus* muscle, terminating at the same point as the first, but proceeding from the inferior extremity of the large cornu of the os hyoides, or styloid bone, instead of its upper part ; its fibres pass beneath the hyo- and thyro-hyoideus muscles, and proceed upwards in crossing the direction of the preceding muscle, terminating on the middle raphé on the superior face. It pulls the upper wall of the pharynx backwards and downwards.

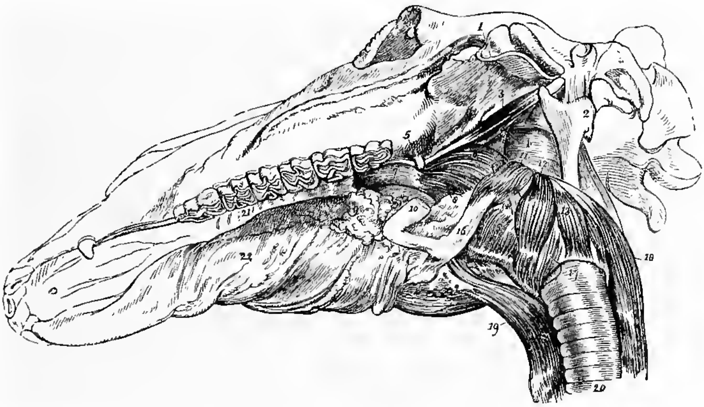
Certain anatomists designate it the inferior stylo-pharyngeus, and consider it as a constrictor of the pharynx. It sometimes exist only on one side.

3. *Vessels and nerves.*—The blood sent to the pharynx comes from the *pharyngeal* and *thyroideal arteries*. The *nerves* are supplied by the *glosso-pharyngeus*, *pneumogastric*, and *great sympathetic*.

FUNCTIONS.—The pharynx plays a passive part in respiration, by serving as an intermediate canal between the nasal passages and the larynx.

Its principal function, however, is connected with the digestive phenomena, by its being an active agent in the first stage of deglutition—a complex and rapid movement, which is executed in the following manner : The bolus of food, propelled by the tongue into the pharynx, is seized by the constrictor muscles,

Fig. 252.



MUSCLES OF THE PHARYNGEAL AND HYOIDEAL REGIONS.

1, Glenoid cavity of temporal bone; 2, superior extremity of styloid bone; 3, tensor palati with its pulley, 5; 4, stylo-pharyngeus; 6, palato-pharyngeus; 7, circumflexus palati; 8, pterygo-pharyngeus; 9, sublingual glaud; 10, portion of hyoid bone; 11, hyo-pharyngeus; 12, thyro-pharyngeus; 13, crico-pharyngeus; 14, portion of stylo-pharyngeus; 15, hyo-thyroideus; 16, styloid bone; 17, crico-arytenoideus lateralis; 18, œsophagus; 19, sterno-maxillaris and hyoideus, and subscapulo-hyoideus; 20, trachea; 21, hard palate; 22, tongue.

which come into action successively from before to behind, in a peristaltic and involuntary manner, to carry the mass to the entrance of the œsophagus. The food thus passes over the opening of the larynx during pharyngeal deglutition, but it cannot enter it, becauses the bolus forces back the epiglottis on this aperture, which it almost exactly closes ; because, also, the passage of the food prevents pulmonary inspiration, which might, if allowed to take place, divert it from its natural course, and throw it into the nasal air-passages. The application of the walls of the pharynx to the pellet of food during its momentary passage over the larynx, prevents all communication between the external air and the lungs, and only permits the elevation of the ribs with the utmost difficulty. The extreme rapidity of the act of deglutition is another reason for the food escaping the larynx.

(Gray concisely remarks: When deglutition is about to be performed, the pharynx is drawn upwards and dilated in different directions, to receive the morsel propelled into it from the mouth. The stylo-pharyngei, which are much further removed from one another at their origin than at their insertion, draw upwards and outwards the sides of this cavity—the breadth of the pharynx, in the antero-posterior direction, being increased by the larynx and tongue being carried forwards in their ascent. As soon as the morsel is received in the pharynx, the elevator muscles relax, the bag descends, and the constrictors contract upon the morsel and convey it gradually downwards into the œsophagus.)

The deglutition of liquids is carried on in a similar manner.

It is curious to remark that, in Solipeds, the food does not come into direct contact with the greater portion of the superior wall of the pharynx during its passage through that cavity. When the alimentary mass is carried back by the tongue, it raises the soft palate and bears the posterior border of this backwards to the entrance of the œsophagus. The extreme development of this palatine curtain, therefore, quite prevents this surface of the pharynx from being directly applied to the food, and it is through the medium of this partition that the constrictors exercise their peristaltic action on the morsel of aliment, until it reaches the œsophageal orifice.

Differential Characters of the Pharynx in the other Animals.

The pharynx of **Ruminants** is elongated and very spacious. The hyo-, thyro-, and crico-pharyngeal muscles—the middle constrictor and inferior constrictors—are less distinct from each other than in the Horse: the inferior constrictor is very small, and the fibrous raphé on which the constrictors unite is little developed. In the pharynx of the **Ox** and **Sheep** is noticed a mucous fold that descends to the middle of the posterior wall, and appears to be a continuation, posteriorly and inferiorly, of the nasal septum; whence results the formation of two glandular pharyngeal cæca at their bottom.

In the **Camel**, this organ is remarkable for the large dimensions of its longitudinal direction and its relative narrowness. The posterior pillars of the soft palate unite at a great distance above the entrance to the œsophagus, and the pharynx appears to be divided into two compartments by a transverse mucous fold, which is detached from the posterior wall. The superior compartment thus formed, shows, above, the guttural openings of the nasal cavities—openings which are narrow and vertically elongated—and the orifices of the Eustachian tubes; while at the bottom of the inferior compartment is the œsophageal infundibulum and the entrance to the larynx. The pharyngeal mucous membrane in this animal is black in colour.

In the **Pig**, the pharyngeal cæcum is sacculated, and its mucous membrane is very vascular, and rich in closed follicles.

In the **Dog**, the infundibulum is very spacious. The posterior pillars of the soft palate subside on the walls of the pharynx before reaching the entrance to the œsophagus. The pharyngeal mucous membrane, much finer than that of the œsophagus, is distinguished from it by a sharp line of demarcation, and here it is very rich in glands. The crico-pharyngeal is not very distinct from the thyro-pharyngeal muscle; so that, in reality, only three constrictors can be distinguished.

Comparison of the Pharynx of Man with that of Animals (Fig. 253).

In consequence of the smallness of the soft palate, the pharynx of *Man* is only a kind of channel between the mouth and the larynx and œsophagus. It is usually divided into three portions: a superior, the *posterior nares*, covered by ciliated epithelium; a middle, or *guttural*, and an inferior, or *œsophageal*. The two latter are covered with tesselated epithelium.

The muscles are almost the same as in the Dog, being a portion of the palato-pharyngeus, the superior, middle, and inferior constrictors, and a stylo-pharyngeal muscle.

Below the sides of the pharynx, and between the pillars of the soft palate, are the *amygdalæ*—almond-shaped organs, the surface of which shows the openings of the follicles that, with the vessels and a little connective tissue, compose their substance.

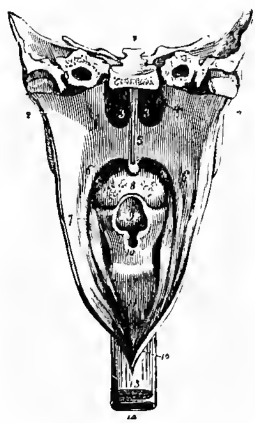
The Œsophagus (Figs. 254, 255).

Preparation.—Place the subject in the second or third position; remove the cervical panniculus from the left side; take away the corresponding anterior limb, and proceed to the excision of the ribs of this side, with the exception of the first. Afterwards dissect the vessels and nerves in the neighbourhood of the œsophagus, taking care to preserve their relations with each other.

Form.—The œsophagus is a long, cylindrical, narrow, membranous canal, a little wider below its commencement, easily dilated for the greater part of its extent, destined to convey the food from the pharynx to the stomach, and so to complete the act of deglutition.

Course.—It begins at the pharynx, and communicates with it by means of the posterior opening situated above the glottis. It is so narrow when not in use, that it admits with difficulty the tip of the finger. Behind, it is circumscribed by a fibro-mucous cord that is related to the junction of the posterior pillars of the soft palate; in front, by the external surface of the arytænoid cartilages. It afterwards descends behind the trachea to the middle of the neck, where it commences to deviate towards the left side of that tube, and enters the thoracic cavity by inclining towards the inner aspect of the first left rib. It soon after regains its situation above the trachea, passes over the base of the heart, and reaches the opening in the right pillar of the diaphragm, in passing between the two layers of the posterior mediastinum. Traversing this opening, it enters the abdominal cavity, and immediately afterwards is inserted into the smaller curvature of the stomach by an orifice designated the *cardiac*, which will be studied at the same time as that viscus.

Fig. 253.



HUMAN PHARYNX LAID OPEN FROM BEHIND.

1, Section through base of skull; 2, 2, walls of pharynx drawn aside; 3, 3, posterior nares, separated by the vomer; 4, extremity of one Eustachian tube; 5, soft palate; 6, posterior pillar of soft palate; 7, anterior pillar; 8, root of the tongue, partly concealed by the uvula; 9, epiglottis overhanging (10) the cordiform opening of the larynx; 11, posterior part of larynx; 12, opening of œsophagus, 13; 14, trachea.

Relations.—The œsophagus in its course has the following numerous relations :—

At its *origin*, it is comprised between the guttural pouch and the posterior crico-arytenoid muscles.

In the *cervical region*, it is enveloped in a thick layer of connective tissue, which unites it in a loose manner to the surrounding organs, its relations with these varying as we consider them superiorly or inferiorly. *Superiorly*, and in the median plane, it occupies the space included between the trachea and the longus-colli, being bordered on each side by the common carotid artery, with its satellite nerves—the trunk common to the great sympathetic and pneumogastric, and the inferior laryngeal. *Inferiorly*, it is related to the trachea on the inner side; and, externally, to the inferior scalenus muscle, and the vessels and nerves in the left cervical channel, which also includes the jugular vein.[1]

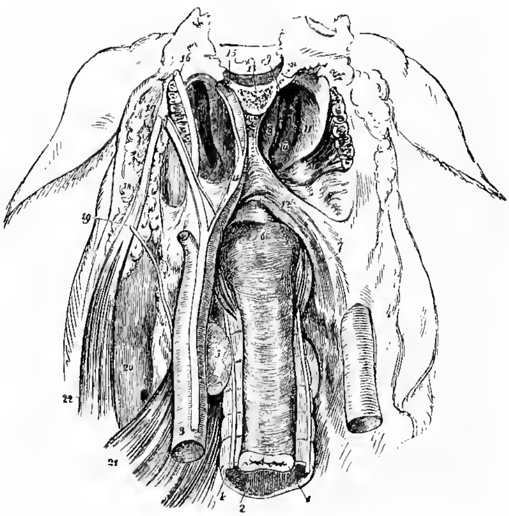
[1] It is not absolutely rare to find the œsophagus deviate to the right in the lower part of the neck; in this case its relations will be reversed. We have never seen this canal enter the thorax in the median plane of the body.

In Horses with a flat trachea, the œsophagus is sometimes in the middle of the upper

At its entrance into the thoracic cavity, the œsophagus, still deviating to the left, and lying on the side of the trachea, responds, externally, to the inferior cervical ganglion, the afferent and emergent nerves of that ganglion, the vertebral arteries and veins, and the superior cervical and dorso-muscular vessels, which obliquely cross its direction. *Beyond this* it regains its position between the trachea and the longus colli, passes above the left bronchus, to the right of the thoracic aorta, until it reaches between the layers of the posterior mediastinum, which bring it into relation with the internal face of the lungs ; these are channeled for its reception, and here it is accompanied by the œsophageal artery, and the œsophageal branches of the pneumogastric nerve.

The *very short portion* lodged in the abdominal cavity is related, on the

Fig. 254.



TRANVERSE VERTICAL SECTION OF HEAD AND NECK IMMEDIATELY IN FRONT OF THE STYLOID PROCESSES, AND BEHIND THE ŒSOPHAGUS.

1, Œsophagus; 2, inner surface of trachea; 3, common carotid artery; 4, recurrent nerve; 5, thyroid gland; 6, exterior of pharynx; 7, crico-pharyngeus muscle; 8, 9, 10, 11, guttural pouch and objects in its interior; 12, stylo-pharyngeus muscle; 13, sphenoid bone; 14, jugular ganglia; 15, internal carotid; 16, 17, pneumogastric nerve; 18, parotid gland; 19, great hypoglossal nerve; 20, jugular vein; 21, subscapulo-hyoideus; 22, stylo-maxillaris.

right, to a fissure in the superior border of the liver, and is enveloped by the peritoneum. It terminates about the upper third of the sixteenth rib.

Interior.—Internally, the œsophagus presents nothing of interest; and it only requires to be remarked, that its walls are always shrunken and in contact when food is not passing between them. It appears narrower in consequence of its inflections or relations with other organs : 1. Near its commencement. 2. At its entrance to the thorax. 3. At its passage through the diaphragm.

STRUCTURE.—The œsophagus has two tunics—a *mucous* and a *muscular*.

The **mucous membrane** is continuous with that of the pharynx and stomach ; it is white, and shows numerous longitudinal folds, which allow the

surface of that tube ; in other cases it is drawn to the inferior face, below the sterno-maxillaris muscles, along with the carotid artery and its satellite nerves, the jugular vein maintaining its position.

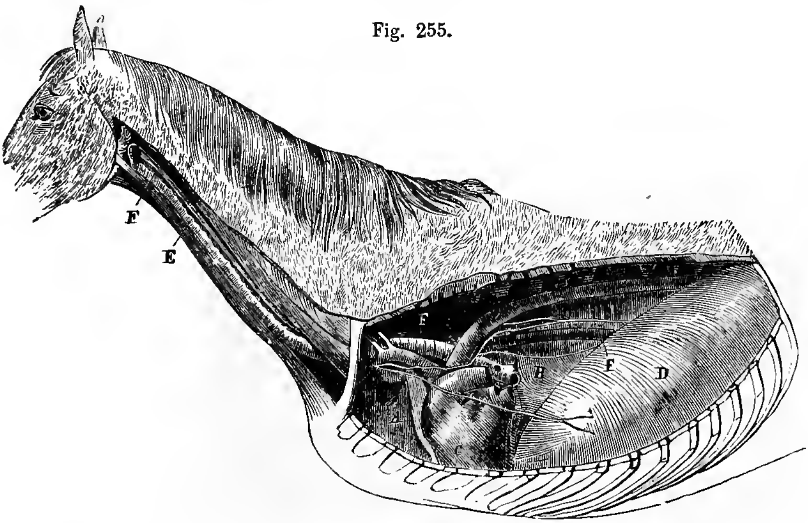
canal to dilate. It adheres but loosely to the muscular coat, on which it can glide with the greatest facility. It has a thick, resisting, stratified, tesselated epithelium, an unstriped muscular layer, and some racemose glands.

(A *third* or *middle* coat is sometimes mentioned by anatomists; it is composed of the tissue connecting the latter tunic with the one to be next described.)

The *muscular coat* commences at the posterior part of the pharynx by the *aryteno-œsophageal* and *superior longitudinal œsophageal muscles* (Fig. 251). The *aryteno-œsophageal* muscle is an extremely thin, small band in Solipeds, situated on the posterior border of the arytænoid cartilage, at the commencement of the œsophagus, where its fibres disappear. To expose this muscle—which represents the inferior longitudinal œsophageal of some authorities, the œsophagus should be turned forwards on the upper surface of the pharynx.

The *superior longitudinal œsophageal* muscle is a small superficial band, the

Fig. 255.



PECTORAL CAVITY AND MEDIASTINUM, SHOWING THE COURSE OF THE TRACHEA AND ŒSOPHAGUS.

A, Anterior mediastinum; B, posterior mediastinum; C, the heart and pericardium in the middle part of the mediastinum; D, diaphragm; E, trachea; F, œsophagus.

fibres of which leave the base of the fibrous triangle that occupies the posterior face of the pharynx, to disappear on the surface of the œsophagus, where some of them form loops at different elevations.

To these muscles at the commencement of the œsophagus, must be added the *crico-œsophageal*, which leaves the deep face of the crico-pharyngeus to pass to the border of the œsophagus, where its fibres proceed above and below that tube, in joining those of the muscle of the opposite side. This muscle compresses the œsophagus at its commencement, in the same way as Wilson's muscle acts upon the urethra.

The remainder of this muscular tunic is formed of superficial longitudinal fibres, often assembled in fasciculi; and of a deeper series of spiral or circular fibres, which, towards the inferior extremity of the canal, intercross in an almost inextricable manner. This muscular layer in the cervical, and for a great part of the thoracic portion of the œsophagus, has almost the red colour of voluntary muscles; but it becomes white, like the involuntary fibres, after the tube enters the mediastinum, and acquires considerable thickness and marked rigidity in the dead animal. It is to be noted that this arrangement of the muscular tunic is especially evident towards the insertion of the œsophagus into the stomach, and that the muscular tube is at this point so narrow, that it is almost exactly occupied by the folds of mucous membrane it contains. For this reason it is that, in this state of cadaveric rigidity, we may inflate a stomach by the pylorus without applying a ligature to the œsophagus; the aperture of the canal being so perfectly closed that it does not allow a bubble of air to escape. In describing the interior of the stomach, we will refer to the consequences resulting from this interesting anatomical fact.

Vessels and nerves.—The œsophagus is supplied with blood by the divisions given off by the common carotid artery, as well as the bronchial and œsophageal arteries. The nerves are almost exclusively derived from the pneumogastric; the motor nerves are the superior œsophageal filaments—branches of the external pharyngeal and laryngeal; the sensitive filaments are derived from the recurrent nerve. For the portion beyond the heart, the sensitive-motor nerves are supplied by the œsophageal nerves of the pneumogastric, though in an asymmetrical manner.

FUNCTIONS.—This canal conveys nutriment from the pharynx to the stomach; it has no other uses.

DIFFERENTIAL CHARACTERS OF THE ŒSOPHAGUS IN THE OTHER ANIMALS.

In all the other domesticated animals, the muscular coat is red-coloured throughout its whole extent, and everywhere offers the same degree of thickness and the same flaccidity. The canal is also as wide towards the stomach as at the pharynx. In RUMINANTS and the CARNIVORA, it enters the stomach as a funnel-shaped (infundibuliform) tube.

In the **Camel**, the mucous membrane adheres more closely to the muscular tissue than in Solipeds, according to Colin.

The dilatability of the œsophagus is very remarkable in these animals: Dogs swallow large pieces of flesh; and Cows and Oxen are able to ingest large turnips, or such voluminous foreign bodies as shoes.

(In Ruminants and the Carnivora the œsophagus is, proportionally, wider than in the Horse and Pig.)

COMPARISON OF THE ŒSOPHAGUS OF MAN WITH THAT OF ANIMALS.

The œsophagus of MAN resembles that of Carnivora; its diameter is almost uniform. It also inclines to the left below the neck, but in the thorax is in the median line, though it again deviates to the left as it joins the stomach. As the thyroid in Man is very voluminous, it is related to the œsophagus in the upper part of the neck. Two small accessory fasciculi, belonging to the muscular tunic of the œsophagus, have been described: one is the *broncho-œsophageal muscle*, which is detached from the left bronchus; and the other the *pleuro-œsophageal muscle*, detached from the left layer of the posterior mediastinum.

ARTICLE II.—THE ESSENTIAL ORGANS OF DIGESTION.

These organs being all contained in the *abdominal cavity*, this common receptacle will first be studied; afterwards the *stomach*, *intestines*, and their *annexed organs*—the *liver*, *pancreas*, and *spleen*—will be described.

The Abdominal Cavity.

In Mammalia, the interior of the trunk is partitioned by the diaphragm into two great cavities, which lodge the majority of the organs so vaguely termed the "viscera." The anterior, the smallest, is the *pectoral* or *thoracic cavity;* the posterior is named the *abdomen*, or *abominal cavity*.

Form of the Abdominal Cavity.—The abdomen is a vast oval-shaped reservoir, elongated from before to behind, having for its upper wall the muscles of the sublumbar region, enclosed below and laterally by the muscles of the inferior abdominal region, bounded in front by the diaphragm, and prolonged behind between the bones and membranous ligaments of the pelvis.

The parts forming the walls of this cavity having been already described, we will confine ourselves to an examination of its interior, in order to determine the various regions into which it is possible to divide it—a matter of some importance, as it singularly facilitates the topographical study of the contained viscera; for to say that an organ is situated in the abdomen, is a very vague reference to its precise situation, in consequence of the great extent of this cavity. It is necessary, therefore, to divide the abdomen into a certain number of peripheral regions which will correspond to the different parts of its wall, with a view to define the situation of the organs lodged therein, yet without complicating anatomical description. Six principal regions are recognized in the abdominal cavity.

A. The *superior*, or *sublumbar region*, corresponds to the superior wall of the abdomen; that is, to the psoas muscles and the bodies of the lumbar vertebræ. It extends from the opening between the two pillars of the diaphragm to the entrance to the pelvis.

B. The *inferior region*, limited, laterally, by the hypochondriacs and the flanks, commences, in front, at the xiphoid cartilage, and is prolonged to the pubis; it comprises all that portion of the abdomen which corresponds to the linea alba and the two recti muscles. Its great extent necessitates its subdivision into five secondary regions: The *supra-sternal region*, named the *epigastric* in Man, placed above the xiphoid cartilage of the sternum; the *umbilical region*, situated behind the preceding, and so named in consequence of its including that part of the wall which is pierced by the umbilicus; the *prepubic region*—the *hypogastric or pubic* of Man—occupies the space in front of the anterior border of the pubis; the *two inguinal regions*, diverticuli of the abdominal cavity, located in the inguinal tracts, where they form the special reservoirs to be hereafter described as the *vaginal sheaths* (or *inguinal canals*).

C. The *lateral regions* (*right* and *left lumbar* of Man) are limited: in front, by the costal attachments of the diaphragm; behind, by the entrance to the pelvic cavity; above, by the superior border of the small oblique muscle; below, by the interval comprised between the inferior border of that muscle and the external border of the great rectus muscle. The designation of *hypochondriac* is given to the sub-region which corresponds to the cartilaginous circle of the false ribs. The *flank* is that section covered by the muscular portion of the small oblique muscle.

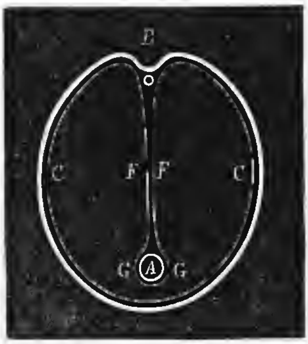
D. The *anterior*, or *diaphragmatic region*, comprises the cavity formed by the posterior face of the diaphragm. Like that muscle, it is divided into two regions, a *central* and *peripheral*.

E. The *posterior*, or *pelvic region*, is a special diverticulum of the abdomen described as the *pelvic cavity*. It is bounded, above, by the sacrum; below, by the superior face of the pubes, the ischia, and the internal obturator muscle; on the sides, by the constricted portions of the ossa innominata and the sacro-sciatic ligaments. The entrance to this diverticulum is situated above the pubes and is of an oval form. Posteriorly, it is narrower, and is traversed by the rectum and the genito-urinary organs, which open externally.

THE PERITONEUM.—The abdominal cavity is lined, internally, by a serous membrane, the *peritoneum*, which will now be briefly described.

Like all the splanchnic serous membranes, the peritoneum is composed of a parietal and a visceral layer, which together form a closed sac so arranged that the organs contained in the abdomen are situated external to this sac. The adjoining theoretical figure (256), representing a transverse section of the abdominal cavity, will show at a glance this arrangement. Let A represent the section of the small intestines floating at liberty in the interior of the cavity; B, that of the aorta, at the level of the great mesenteric artery: the peritoneal membrane, C C, covers the walls of the abdomen, and at the points D, D is folded around the great mesenteric artery, in such a manner as to form two layers, F, F, which come in contact by their adherent faces, reach the intestine, and then separate to envelop it. We then see in this figure the parietal layer of the peritoneum C C, the visceral layer, G G, and the two layers, F, F, which establish the continuity of the parietal and visceral portions; the complete sac formed by these is apparent, and it could be rendered more so by the further separation and development of the layers F, F; so that there is no difficulty in understanding how the small intestine may be at the same time *in the interior* of the abdominal cavity, and *outside* the sac formed by the serous membrane which lines that cavity.

Fig. 256.



THEORETICAL TRANSVERSE SECTION OF THE ABDOMINAL CAVITY, TO SHOW THE DISPOSITION OF THE PERITONEUM.

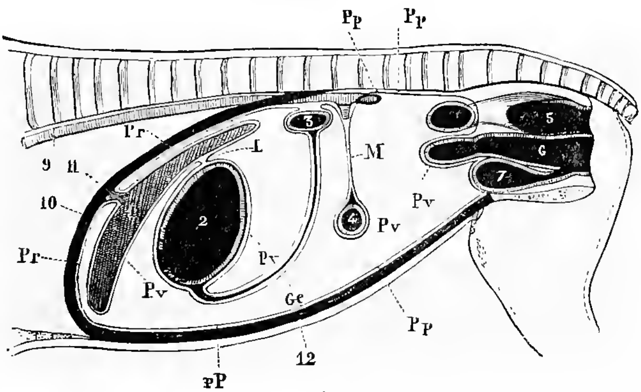
This arrangement is common to all the organs freely suspended in the abdomen. The serous folds which suspend them, in joining their peritoneal layer to that which covers the parietes of the cavity, will be studied under the names of *ligaments*, *mesenteries*, and *omenta*. Some organs—the kidneys, for example—have no proper visceral layer, being contained between the abdominal wall and the external face of the parietal peritoneum, and are invested with none of the duplicatures just mentioned.

We will briefly study the duplicatures, ligaments, mesenteries, and omenta that the peritoneum forms, starting from the umbilicus and passing forwards and backwards (Fig. 257).

On reaching the supra-sternal region, the peritoneum forms a *falciform* duplicature, extending from the umbilicus to the middle lobe of the liver, and which is even prolonged between that lobe and the posterior face of the diaphragm; at the free border of this fold is a thickening, which is regarded as the remains of the obliterated umbilical vein. In becoming doubled over the neighbouring organs, the diaphragmatic portion constitutes: 1. The *ligaments of the right* and *left lobes of the liver*. 2. The *common ligament* of that gland, which surrounds the posterior vena cava. 3. The *cardiac ligament* that envelops the termination of the œsophagus. Behind the liver is found the *hepato-gastric ligament*, which fixes the stomach in the posterior fissure of the liver, and is, to the right and backwards, attached to the duodenum at the lower face of the right kidney; it is then directed from right to left, and becomes continuous with the parietal peritoneum of the sublumbar region and the *mesentery* proper.

The two layers of the hepato-gastric ligament separate at the lesser curvature of the stomach, to cover that viscus; then join at its greater curvature, and pass to the interior of the abdominal cavity. This fold receives the name of the *great* or *gastro-colic omentum*; it leaves the left tuberosity of the ventriculus, which it suspends to the sublumbar region from the whole extent of the great curvature; to the right it goes beyond the pylorus, to be continued on the concave curvature of the duodenum, as far as the cæcum. By its posterior border, the great omentum is extended around the termination of the large colon and the origin of the floating colon, where it is confounded with the visceral peritoneum of these organs, as well as with the parietal peritoneum. It results from this arrangement, that the great omentum forms behind the stomach, and in front of the adherent portion of the large colon, a space that communicates with the great peritoneal cavity by a very narrow opening—the *foramen of Winslow*. This aperture is included between the vena portæ, posterior vena cava, anterior extremity of the pancreas, and the lesser curvature of the stomach. To the left of the latter viscus, on the

Fig. 257.



THEORETICAL LONGITUDINAL AND MEDIAN SECTION OF THE ABDOMINAL CAVITY, TO SHOW THE REFLECTIONS OF THE PERITONEUM.

1, Liver; 2, stomach; 3, small intestine; 4, origin of the floating colon; 5, rectum; 6, vagina and uterus; 7, bladder; 9, posterior aorta; 10, diaphragm; 11, posterior vena cava; 12, inferior abdominal wall. Pp, Pp, parital peritoneum; Pv, Pv, visceral peritoneum, L, gastro-hepatic ligament; M, mesentery; Ge, great omentum.

external face of the great omentum, the spleen is suspended; consequently, that portion extending from the spleen to the ventriculus, is named the *gastro-splenic omentum*.

The two layers composing the great omentum are very thin for the greater part of their extent, and enclose the blood-vessels between them. In emaciated animals, these vessels are distinctly seen, owing to the transparency of the membranes, and they give the omentum a lacework appearance; but in fat subjects they are concealed by the adipose tissue deposited along their course, and which may accumulate in considerable quantity.

In the sublumbar region, the parietal peritoneum forms several folds; these are: the *hepatico-renal ligament*, extending from the right lobe of the liver to the anterior border of the right kidney; the *ligament of the lobus Spigelii*, the *mesentery* proper, the *colic mesentery*; lastly, the greatly developed layers surrounding the cæcum and the second flexure of the colon, which constitute the *meso-cæcum* and *meso-colon.*

The *great mesentery* is detached from around the large mesenteric artery, and projects into the abdominal cavity to reach the small intestine at the lesser curvature, and to envelop that viscus.

Its shape is that of an irregular triangle, the summit of which corresponds to the mesenteric artery, the very short anterior border being continuous with the duodenal frænum, and the posterior border, the longest, with the meso-colon, its convex festooned base being as long as the intestine itself. Between the two layers that compose it, are the blood-vessels and lymphatics, as well as the nerves, of the small intestine.

The *colic mesentery* is formed like the great mesentery. Its inferior border, plane or plicated, is fixed to the small curvature of the floating colon and the commencement of the rectum ; its upper border extends from the great mesenteric artery, as far as the entrance to the pelvic cavity.

Around the cross of the cæcum, from the origin to the termination of the great colon, the peritoneum is reflected to cover these viscera ; a layer passes from the anterior border of the cæcum on to the ileum and the second flexure of the colon—this is the *meso-cæcum ;* another layer, comprised between the second and third portion of the colon—the shape of which is that of a battledore, is named the *meso-colon.*

If, again, the peritoneum is taken at the umbilical region and followed backwards, it will be found to insinuate itself into the inguinal canals, cover the organs contained in the pelvis, and become reflected at the bottom of that cavity, to be continued either with the peritoneum of the sublumbar region, or with that on the lateral walls of the abdomen.

This serous membrane covers the fundus of the bladder, and at this point it has three ligaments. The *middle ligament,* falciform in shape, leaves the large extremity of the bladder, is attached to the anterior border of the pubis, and insensibly disappears on the inferior abdominal wall ; on its free border is a small fibrous cord, which is supposed to be the remains of the urachus. The *two lateral ligaments* are more developed, and extend from the entrance to the pelvic cavity to the vesical fundus ; they have on their free border the obliterated umbilical arteries. In the male, the peritoneum is prolonged from the upper face of the bladder to the enlargement of the deferent ducts, between which it sends a transverse fold to the anterior extremity of the vesiculæ seminales, and is then reflected around the rectum.

In the female, it is carried from the bladder to the terminal portion of the vagina, to the uterus, and to the cornua of that organ, where it forms three folds named the *broad ligaments*, *ligaments of the ovary*, and the *round ligament ;* then it re-descends on the upper face of the vagina, and thence envelops the rectum, around which it is reflected from behind forwards.

According to this arrangement, we see that the termination of the digestive canal, and the parts of the genito-urinary organs situated altogether at the posterior portion of the pelvic cavity, are placed outside the peritoneal serous membrane.

STRUCTURE.—Like all the serous membranes, the peritoneum is formed by a membrane of connective tissue, rich in elastic fibres, and covered on its free face by an endothelial layer (the cells of which are flat and polygonal, and about $\frac{1}{1200}$ of an inch in diameter). Many *blood-vessels* are found on the adherent surface ;

while *lymphatics* are abundant in the visceral layer ; they are independent, or form a sheath around the blood-vessels of the mesentery. Its *nerves* come from the diaphragmatic, lumbar, and intercostal branches, and the great sympathetic.

Differential Characters in the Abdominal Cavity of the other Animals.

In the Carnivora, the abdominal cavity is very narrow; while in Ruminants it is very vast, its capacity being in direct relation to the volume of the viscera it contains.

The general arrangement of the peritoneum varies but little in the different species, the only notable diversities being remarked in the great omentum. In the **Ox, Sheep,** and **Goat,** this is detached from the middle of the lower face of the rumen, and envelops the right sac of that organ, fixing the fourth compartment to its great curvature, and then passing upwards, to become continuous with the mesentery. In the **Dog** and **Pig,** this fold descends in front of the intestinal mass, until near the pelvis; then it ascends in gathering on itself, and ultimately spreads over the colon; in the middle portion of the great omentum there are, consequently, four layers laid against each other.

Comparison of the Abdominal Cavity of Man with that of Animals.

The abdominal cavity of Man is elongated vertically, and has an inferior cavity occupying the entrance to the pelvis. There is nothing particular to note in its disposition, the differences observed in it being allied to the external shape of the body. The peritoneum is spread over its parietes nearly in the same manner as in the Carnivora; the great omentum is formed by four layers, and covers the intestines like an apron; between its two layers is the *lesser cavity* of the omentum, virtually in the adult.

The Stomach.

The *stomach* is a membranous sac placed between the œsophagus and intestines, and in which is completed the division of the alimentary matters.

1. The Stomach in Solipeds (Figs. 258, 259, 260, 261)

Preparation.—In order to study the relations of this organ, it suffices to open the abdomen and remove the intestinal mass in the following manner: Place the animal in the first position, and very slightly inclined to the left side; make an incision through the inferior abdominal wall, or, still better, carry it away entirely by a circular incision, taking care not to wound any part of the intestine. The entire viscera should then be withdrawn from the abdominal cavity, and laid on the table which supports the subject; for this mass cannot be allowed to fall on the ground without risk of being pulled and torn, either in the intestine itself, or those parts which it is desired to preserve intact in the abdomen. Incise the floating colon where it joins the rectum, and the duodenum where it passes behind the great mesenteric artery; the base of the cæcum should now be detached from the sublumbar surface by the rupture of the connective tissue which connects it to the right kidney and the pancreas; the cellular connection between the latter gland and the terminal extremity of the fourth portion of the large colon should also be broken; after this, it is only necessary to divide the attachment of the mesenteric bands to the sublumbar region, with the vessels contained between them. The intestinal mass is then definitely expelled from the abdominal cavity. In this way it is possible to expose, and conveniently prepare, not only the stomach, but also the spleen, liver, pancreas, kidneys, ureters, etc. Nothing more remains than to make known the procedure to be adopted in everting the stomach, in order to study its internal surface, or dissect its deep muscular layer. It is recommended, first, to excise the stomach with at least three inches of the œsophagus, and eight inches of the duodenum, and cleanse the interior of the organ. This may be done in several ways, but the following is the simplest: a certain quantity of water is introduced into the stomach by fixing the duodenum to a water-tap, the right hand manipulating the organ while the left closes the duodenum to prevent the escape of the liquid. The alimentary substances contained in it are in this way mixed with the water, and may be expelled from the duodenum by pressing the stomach; this operation, being repeated four or five times, thoroughly cleanses the cavity of the organ. To evert the inner surface, it is only necessary to introduce by the duodenum a loop of wire, and make it pass through the œsophagus; a strong waxed thread is fastened in the loop and firmly fixed around the œsophagus, when, in pulling back the wire, this extremity is drawn towards the pylorus, and by careful traction the latter is so dilated as to allow the passage of the cardiac end, and complete eversion of the stomach. Inflation will then give it its normal form and disposition; with this difference, that the mucous membrane is external, and the serous tunic internal.

Lastly, to render the muscular layers of the stomach more evident, it is advisable to plunge the organ into boiling water for some minutes, after which it should be put into cold water. If it is desired to study the external and middle layers, the stomach should be inflated, and its serous covering removed by strips with forceps and the fingers; if the deep layer is to be

Fig. 258.

THE ABDOMINAL CAVITY, WITH THE STOMACH AND OTHER ORGANS.

1, Right lobe of liver; 2, middle lobe; 3, right extremity, or ventriculus of stomach; 4, left extremity; 6, left kidney; 7, supra-renal capsule; 8, ureter; 9, posterior vena cava; 10, posterior aorta; 11, 12, psoas parvus and magnus; 13, iliacus; 14, tensor vaginæ; 15, external iliac artery; 16, internal iliac artery.

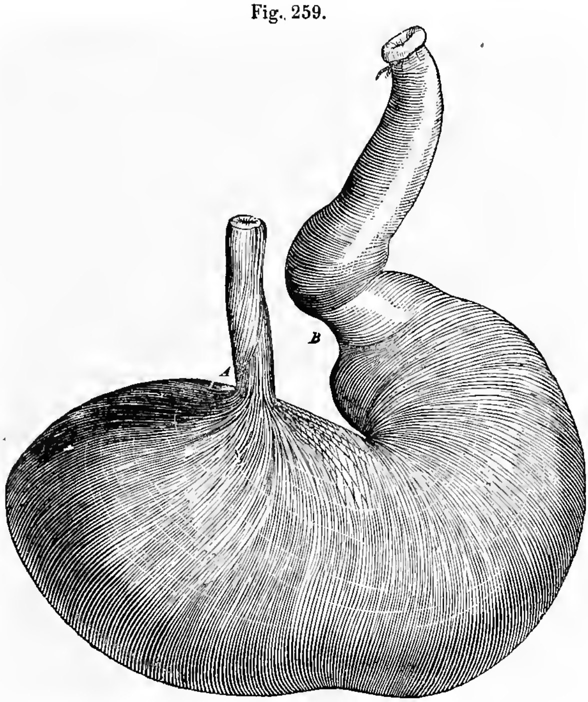
examined, the mucous membrane must be removed by means of the forceps and scalpel from a stomach previously everted.

Situation.—The *stomach*, also designated the *ventriculus*, is situated in the diaphragmatic region of the abdomen, where it has a direction transverse to the median plane of the body.

Dimensions.—Its average capacity, in an ordinary-sized Horse, is from 3 to $3\frac{1}{2}$ gallons; but it varies greatly according to the bulk of the animal, its breed, and the nature of its food. Relatively, it is more considerable in common-bred Horses, and in the Ass and Mule. When empty, its average weight is between 3 and 4 pounds.

Form.—Elongated laterally, curved on itself, often constricted in its middle, and slightly depressed from before to behind, this reservoir presents, externally: 1. *Two faces*—an *anterior* and *posterior*, smooth and rounded. 2. A *great* or *convex curvature*, forming the inferior border of the organ, and giving attachment, throughout its extent, to the great omentum—a membranous fold which has been described as a dependency of the serous membrane. 3. A *lesser* or *concave curvature*, into which the œsophagus is inserted, and which is united, to the right of that canal, to the liver, by means of a frænum known as the hepato-

Fig. 259.



STOMACH OF THE HORSE.

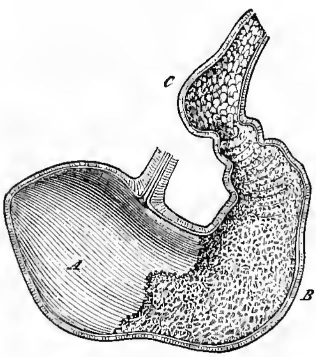
A, Cardiac end of the œsophagus; B, pyloric end and ring.

gastric ligament. 4. A *left extremity* (the *cardiac*), dilated in the form of a large conical tuberosity, and constituting the *left cul-de-sac* (or *fundus*) of the stomach. 5. A *right extremity* (the *pyloric*), narrower, curved upwards, and continued by the duodenum, from which it is separated by a marked constriction—this is the *right cul-de-sac* of the stomach.

Relations.—Studied in its connections with the neighbouring organs, the stomach is related: by its anterior face, with the diaphragm and liver; by its posterior face, with the diaphragmatic curvature of the colon. Its inferior border, margined to the left by the spleen, which is suspended from it by means of the great omentum, is separated from the inferior abdominal wall by the large anterior flexures of the colon; its distance from this wall depends upon the fulness of the organ. The left extremity, suspended to the sublumbar region by the aid of a very short serous ligament—a portion of the great omentum—is related to the base of the spleen, the left extremity of the pancreas, and, less directly, to the anterior border of the left kidney. The right extremity, lower than the left, touches the right lobe of the liver and the above-mentioned intestinal curvatures.

Interior.—When a stomach is opened to study its interior, one is at first struck by the different aspect its internal membrane presents, according as it is examined to the right or the left. To the left, it has all the characters of the œsophageal mucous membrane, in being white, harsh, and even resisting; it is covered by a thick layer of epithelium. To the right, it is thick, wrinkled, spongy, very vascular and follicular, has a reddish-brown tint that is speckled by darker patches, loses its consistency, and is only covered by a very thin epithelial pellicle. It is not by an insensible, but a sudden transition that the mucous membrane of the stomach is thus divided into two portions; and their separation is indicated by a salient, more or less sinuous, but sharply marked ridge. This ridge, then, divides the stomach into two compartments—a division already indicated externally, by the circular depression observed in the majority of subjects. The *left sac* or *compartment* is considered as a dilatation of the œsophagus. The *right sac* constitutes the true stomach of Solipeds; as on it alone devolves the secretory function which elaborates the gastric juice, the essential agent of digestion in this organ.

Fig. 260.



INTERIOR OF THE HORSE'S STOMACH.
A, Left sac; B, right sac; C, duodenal dilatation.

The interior of the stomach (Fig. 260) offers for study two apertures: the *cardiac* and *pyloric*. The *cardiac*, or *œsophageal orifice*, is in the lesser curvature of the left sac of the stomach. Its arrangement have given rise to numerous discussions, as in it has generally been sought the reason why Solipeds vomit with such extreme difficulty. At one time there was described a semilunar or spiroidal valve, which is opposed to the retrograde movement of the food; and at another time it was the oblique insertion of the œsophagus, resembling that of the ureters into the bladder, and which, by a mechanism analogous to these, proved an obstacle to the return of aliment into that œsophagus. Both suppositions are wrong. When we attentively observe the manner in which the œsophagus comports itself at its termination, it will be noticed that it is inflected downwards, after traversing the right pillar of the diaphragm, and is inserted almost perpendicularly into the lesser curvature of the stomach. In opening into this viscus, the œsophagus does not widen into an infundibulum, as in other animals; on the contrary, its calibre is here narrower than elsewhere, and its cardiac or stomachal orifice, completely obstructed by the folds of mucous membrane, only occupies an infinitely small portion of the internal surface of the stomach.

With regard to the *pylorus*, it represents a large aperture formed at the bottom of the right sac, and furnished with a thick circular ring; this opening can be completely closed through the action of the powerful sphincter surrounding it. It is furnished with a valve (the *pyloric valve*), formed by the union of the cellular and mucous tunics, and the sudden disappearance of the circular muscular fibres.

STRUCTURE.—The parietes of the stomach are formed by three membranes: an external, or *serous*; a middle, or *muscular*; and an internal, or *mucous*.

1. *Serous membrane.*—This membrane, derived from the peritoneum, adheres closely to the muscular layer, except towards the curvatures. At the lesser curvature, it is constantly covered by an expansion of yellow elastic tissue, the use of which appears to be to maintain the two extremities of the stomach near each other; for when this is destroyed, the lesser curvature becomes considerably elongated. Along the whole of the greater curvature is a triangular space occupied by connective tissue; this space disappears more or less completely as the organ becomes distended.

It has three folds, which are detached from the stomach and carried on to the adjacent parts, and are formed in the manner indicated in the general description of the peritoneum. These folds constitute the *cardiac ligament*, the *gastro-hepatic ligament* or *omentum*, and the *great omentum*.

The *cardiac ligament* is a short, serous band developed around the terminal extremity of the œsophagus, and strengthened by fibres of yellow fibrous tissue. It attaches the stomach to the posterior face of the diaphragm, and is continuous, on each side, with the two folds about to be described.

The *gastro-hepatic* (or *lesser*) *ligament* is a band composed of two layers, which leave the lesser curvature of the stomach, and are inserted into the posterior fissure of the liver. It is prolonged posteriorly, and to the right, along the duodenum, where it constitutes a peculiar serous frænum, which will be studied with the small intestine.

The *great* or *gastro-colic omentum*, is detached from the whole extent of the great curvature, from the cardia to the pylorus, beyond which it extends to the duodenum. The portion surrounding the left *cul-de-sac* is excessively short, and is carried to the sublumbar wall of the abdomen, to which it fixes the stomach. For the remainder of its extent, this omentum is greatly developed, and hangs freely in the abdominal cavity, among the intestinal convolutions. The border opposed to the stomach is attached to the terminal portion of the large colon, and to the origin of the floating colon. (For further details, see the description of the peritoneum.)

These three ligaments fix the stomach in the abdominal cavity, in addition to the œsophagus and duodenum, which are continuous with it.

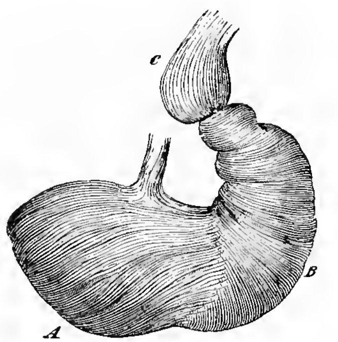
2. *Muscular membrane.*—This tunic, comprised between the serous and mucous layers, is lined internally by a *covering* of condensed connective tissue which adheres intimately to it, and may be regarded as the *fibrous membrane* of the stomach. Dissection shows this muscular tunic to be composed of three superposed planes.

The *superficial plane* envelops all the right sac, and the majority of its fibres are spread in loops around the left *cul-de-sac*, their extremities being lost on the surfaces of the organ. Some of them even extend over the great curvature, to the surface of the right sac; while others are evidently continuous with the superficial fibres of the œsophagus (Fig. 261, A).

The *middle plane* (Fig. 261, B) is formed of circular fibres spread over the whole of the organ. In the right sac, they are placed immediately beneath the serous membrane; in the left sac, they pass beneath the fibres of the superficial plane, and finish by becoming mixed so intimately with these, that towards the tuberosity formed by the left extremity it is impossible to distinguish them. By their aggregation around the pylorus, they constitute the sphincter (or pyloric valve) which envelops that orifice.

The *deep plane* (Fig. 261, A), like the first, is specially destined for the left sac, and cannot be properly studied except in an averted stomach deprived of its mucous membrane. Much thicker than the superficial plane, it yet, in its general arrangement, much resembles it. Thus, its fasciculi present loops which embrace the left *cul-de-sac*, and the extremities of which are lost on the faces of the organ, where some of them become continuous with the circular fibres. The loops nearest the œsophagus embrace the stomachal opening of that canal like a cravat. It is to be remarked that the fibres of this deep layer intersect those of

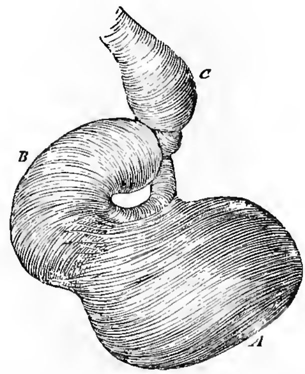
Fig 261.



MUSCULAR FIBRES OF THE STOMACH (EXTERNAL AND MIDDLE LAYERS).

A, Fibres of the external layer enveloping the left sac; B, fibres of the middle plane in the right sac; C, fibres of the pylorus.

Fig. 262.



DEEP AND MIDDLE MUSCULAR LAYER EXPOSED BY REMOVING THE MUCOUS MEMBRANE FROM AN EVERTED STOMACH.

A, Deep layer of fibres enveloping the left sac; B, fibres of the middle plane which alone form the muscular layer of the right sac; C, fibres of the pylorus.

the superficial plane—the former passing from the left to the right sac, in inclining downwards towards the great curvature, while the latter are directed to the right and slightly upwards.

From this arrangement it results, as a glance at Figs. 261 and 262 will show: 1. That the right sac has only a singular muscular plane. 2. That, on the contrary, the left sac has three, all of which concur in propelling the aliment that has accumulated in the left, or œsophageal reservoir, into the right, or true stomach.

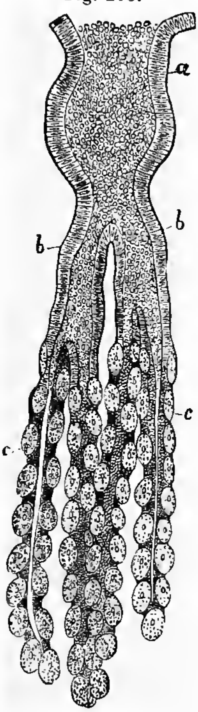
3. *Mucous membrane.*—Independently of the general characters noted in the interior of the stomach, it has to be remarked that the gastric mucous membraue is united to the preceding tunic by an expansion of connective tissue; though it adheres but feebly throughout the right sac, especially towards the greater curvature, where it is thickest; and that it has no ridges in the left sac, though in the right they are always present, even when the organ is inflated.

On the surface of this membrane are seen microscopical apertures (*alveoli*)—the orifices of the excretory ducts of glands; these are rare in the left sac, but extremely numerous in the right. In this region they are separated from each other by minute processes resembling papillæ; but the latter are only met with in the vicinity of the pylorus.

The gastric mucous membrane is composed of an *epithelial layer* and a *corium*, in which are distinguished a *glandular* and a *muscular layer*. The epithelium is stratified and tesselated in the left compartment, simple and calyciform in the right sac, where it covers the little mucous processes that separate the glandulæ, and penetrates more or less deeply into the interior of these, becoming spheroidal.

In the left side, in the vicinity of the pylorus, there are found some racemose glands analogous to those of the œsophagus; but the real *glandular*

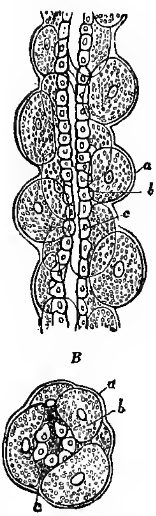
Fig. 263.



PEPTIC GASTRIC GLAND.

a, common trunk; *b*, *b*, its chief branches; *c*, *c*, terminal cæca, with spheroidal gland-cells.

Fig. 264.



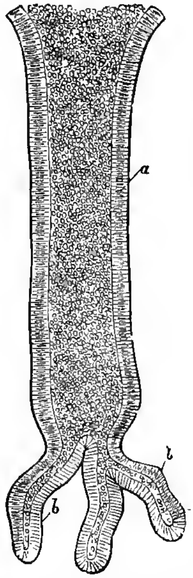
PORTIONS OF ONE OF THE CÆCA MORE HIGHLY MAGNIFIED, AS SEEN LONGITUDINALLY (A), AND IN TRANSVERSE SECTION (B).

a, Basement membrane; *b*, large grandular cell; *c*, small epithelial cells surrounding the cavity.

layer is only to the right side. There are found multitudes of parallel tubular glands, united by a small quantity of delicate connective tissue which is very rich in nuclei. They secrete the gastric fluid, or furnish the mucus that covers the surface of the epithelium; they are consequently distinguished as *pepsine* (or *peptic*) and *mucous glands*, the former being much more numerous than the latter.

They are composed of a simple straight tube at their origin (excretory duct), which frequently divides into two or more flexuous tubes that terminate in *culs-de-sac* (or *glandular cæca*). The epithelium is not the same in the two kinds of glands: the mucous glands (Fig. 265, *a*, *b*) are lined with cylinder-epithelium throughout their extent; the peptic glands (Figs. 263, 264) are lined with cylinder-epithelium at their origin (Fig. 263, *a*), but the secretory tubes contain round peptic cells. (Each cæca, when highly magnified, is found to consist of a delicate basement membrane (Fig. 265, *a*) inflected over a series of nearly globular cells (*b*), which occupy almost the whole cavity of the tube, and contain a finely granular matter; the narrow passage left vacant in the centre is, however, still surrounded by a layer of epithelial cells (*c*), the small size of which is in striking contrast to the large dimensions of the gland-cells.)

Fig. 265.

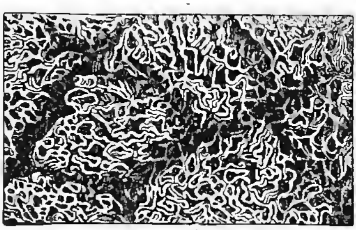


MUCOUS GASTRIC GLAND WITH CYLINDER EPITHELIUM.
a, Wide trunk; *b*, *b*, its cæcal appendage.

The *muscular layer* (of the mucous membrane) is immediately beneath the glandular structure, and contains two planes of intersecting fibres. Lastly, the connective tissue layer of the corium is thick and loose, sustains the vessels (and nerves), and unites the mucous to the muscular tunic of the stomach.

4. *Vessels and nerves.*—The stomach receives its blood by the two branches of the *gastric artery*, the *splenic* and its terminal branch—the *left epiploic artery*, and by the *pyloric* and *right epiploic arteries*. The principal arterial ramifications extend between the mucous and muscular layers, where they furnish two capillary reticulations to the glandular layer—a deep network that surrounds the secretory tubes, and a superficial placed between the alveoli. The blood is carried from the organ to the vena portæ by the satellite *venous branches*. The *lymphatics* form a subserous and two deep networks at the base of the glandular layer and in the fibrous membrane. They enter small glands situated along the curvatures, and from these to Pecquet's reservoir. The *nerves* are derived from the pneumo-gastrics and solar plexus, and in accompanying the vessels show microscopic ganglia in their course; their mode of termination is not known.

Fig. 266



A

B

APPEARANCE OF THE PROPER GASTRIC MEMBRANE OF THE STOMACH IN AN INJECTED PREPARATION (HUMAN).

A, From the convex surface of the folds, or *rugæ*; B, from the neighbourhood of the pylorus, where the orifices of the gastric follicles occupy the interspaces of the deepest portions of the vascular network.

FUNCTIONS.—In the stomach is begun those transformations by which alimentary matters are rendered capable of being assimilated. There the food comes into contact with the gastric fluid, by the action of which its principal elements, and particularly the albuminoid substances, become soluble and absorbable.

Differential Characters in the Stomach of the other Animals.

The stomach is an organ that exhibits great differences in the various domesticated animals. In the study of these differences, we will proceed from the simple to the complex.

1. The Stomach of the Rabbit (Fig. 286).

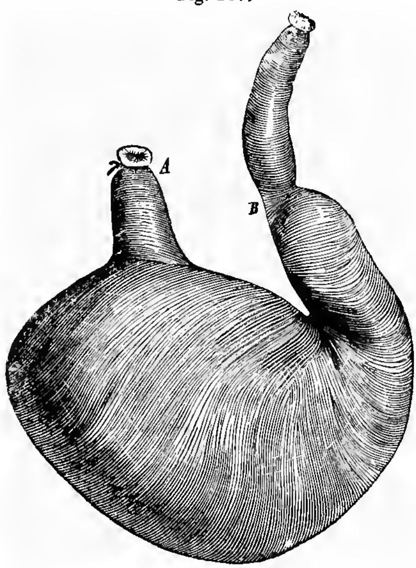
The stomach of the **Rabbit** is described immediately after that of Solipeds, because of the great resemblance between the two organs. Like the latter, the stomach of the Rabbit is divided into two sacs—a right and left—and the œsophagus enters it at the middle of its smaller curvature; so that the organ shows a large tuberosity in *cul-de-sac* on the left of the cardia. The sac is perhaps more elongated, narrower, and more curved than in that of the Horse. The total capacity of the organ is from ¾ of a pint to 1 pint.

2. The Stomach of the Pig (Fig. 289).

The **Pig's** stomach is simple, like that of the Horse, but it is less curved on itself, and the cardia is nearer the left extremity; the latter has also a small conical dilatation, which has been compared to a cowl curved backwards. The œsophagus opens into the stomach by a wide infundibulum, and the mucous membrane of that tube is prolonged over the gastric surface in a radius of from two to three inches around the cardia. Here again we find a "trace of the division into two sacs," common to Solipeds, and to nearly all Rodents.

The capacity of the **Pig's** stomach averages from 1½ to 2 gallons. (The muscular tunic is thicker in the right than the left extremity; near the œsophagus, the serous tunic shows some transverse folds.)

Fig. 267.



STOMACH OF THE DOG.
A, Œsophagus; B, pylorus.

3. The Stomach of Carnivora (Fig. 267).

In the **Dog** and **Cat** the ventriculus is but little curved, and is pear-shaped, the small extremity corresponding to the pylorus. The cardia is dilated like a funnel, and is nearer the left extremity of the organ than in other animals. The œsophageal mucous membrane is not continued beyond the margin of that orifice. The simple stomach of Carnivora forms only a single sac, whose internal mucous membrane presents, throughout its whole extent, the same organization as the membrane lining the right sac of Solipeds. This membrane is remarkable for the regular and undulated folds it forms when the stomach is empty. Nothing is more variable than the capacity of the Dog's stomach, because of the great differences in the size of this animal, according to breed. Colin has found the minimum to be 1¼ pints, and the maximum 1¾ gallons; he calculates the average to be about 2½ quarts. In the Cat, the average is from 2 to 2¼ gills.

4. The Stomach of Ruminants (Fig. 268).

These animals are distinguished from the others by the faculty they possess of swallowing their food after imperfect comminution, and causing it to return again into the mouth to submit it to a second mastication, previous to final deglutition. The gastric apparatus is admirably arranged to effect this physiological finality, and is remarkable for its enormous development, as well as its division into four separate pouches, which are regarded as so many stomachs.

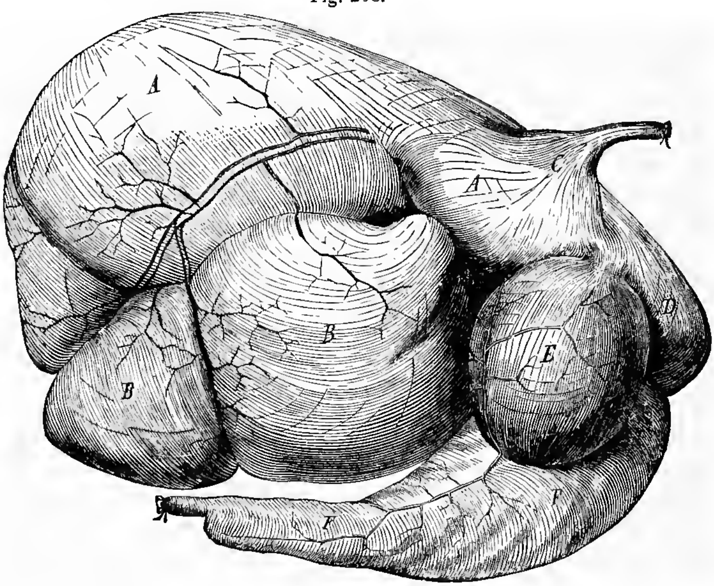
These cavities represent a considerable mass that fills the greater part of the abdominal cavity, and the medium capacity of which is not less than fifty-five gallons! One of them, the *Rumen*, into which the œsophagus is inserted, constitutes nine-tenths of the total mass. The other three, the *Reticulum*, *Omasum*, and *Abomasum*, form a short chain, continuous with the left and anterior portion of the rumen. The abomasum alone should be considered as a true stomach, analogous to that of the Dog, or the right sac of the ventriculus of Solipeds. The other three compartments only represent, like the left sac in the latter animals, œsophageal dilatations.

The description about to be given of each of these divisions more particularly applies to the **Ox**; care will be taken, in the proper place, to note the special peculiarities in the stomach of the **Sheep, Goat,** and **Camel.**

Rumen (Figs. 268, 271).—This reservoir, vulgarly designated the *paunch*, alone occupies three-fourths of the abdominal cavity, in which it affects a direction inclined from above to below, and from left to right.

External conformation.—Elongated from before to behind, and depressed from above to

Fig. 268.



STOMACH OF THE OX, SEEN ON ITS RIGHT UPPER FACE, THE ABOMASUM BEING DEPRESSED.

A, Rumen, left hemisphere; B, rumen, right hemisphere; C, termination of the œsophagus; D, reticulum; E, omasum; F, abomasum.

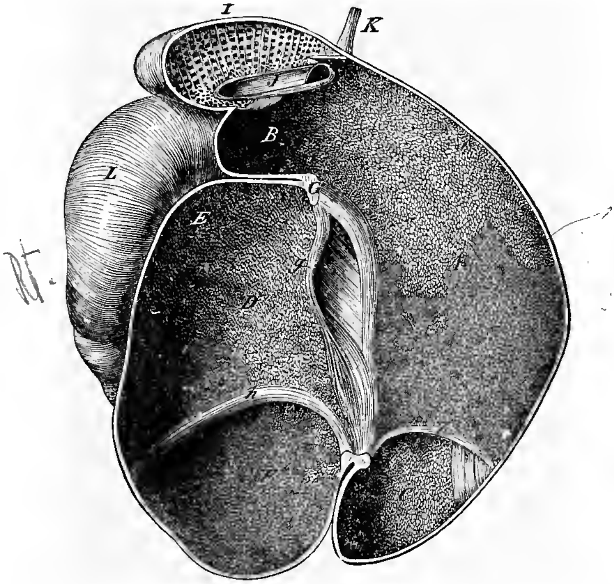
below, it offers for study: 1. An *inferior* and a *superior* face, nearly plane, smooth, and divided into two lateral regions by traces of fissures, which are only sensible at the extremities of the organ. 2. A *left* and *right border*, smooth, thick, and rounded. 3. A *posterior extremity*, divided by a deep notch into two lobes, described by Chabert by the name of *conical cysts*. 4. An *anterior extremity*, offering an analogous arrangement, and concealed, at first sight, by the stomachs (or compartments) superadded to the rumen; the notch on the right of this extremity divides it into two unequal pouches, which will be referred to presently.

It is to be remarked that these two notches, which are prolonged on the surface by furrows that separate these into two lateral regions, divide the rumen into *two sacs*—a *right* and *left*; this division we shall find more manifest in the interior of the viscus. The *right sac*—the shortest—is in great part enveloped by the serous covering which constitutes the great omentum. The *left sac* surpasses the other by its two extremities, except in the **Sheep** and **Goat** (Fig. 271), in which the right conical cyst is longer than the left. The anterior extremity of this left sac is thrown back on the corresponding lobe of the right sac; above, it receives the insertion of the œsophagus, and is continuous, in front, with the reticulum.

Relations.—The external form of the rumen being determined, the study of its relations becomes easy. By its superior surface, it is in contact with the intestinal mass; its opposite face rests on the inferior abdominal wall. Its left border, supporting the spleen, touches the most elevated part of the flank and the sublumbar region, to which it adheres by cellular tissue, as well as the vicinity of the cœliac trunk and the great mesenteric artery; the right border, margined by the abomasum, responds to the most declivitous portion of the right hypochondriac and flank, as well as to the intestinal circumvolutions. The anterior extremity, bounded by the reticulum and omasum, advances close to the diaphragm; the posterior occupies the entrance to the pelvic cavity, where it is more or less in contact with the genito-urinary organs lodged there. In the pregnant female, the uterus is prolonged forwards on the upper face of the viscus just described.

Interior (Fig. 269).—In the interior of the rumen are found incomplete septa, which repeat the division into two sacs already so marked externally. These septa are two in number, and represent large muscular pillars, which correspond inferiorly to the notches described at the extremities of the organ. The *anterior pillar* (Fig. 269, G) sends to the inferior wall of

Fig. 269.



INTERIOR OF THE STOMACH IN RUMINANTS, SHOWING THE UPPER PLANE OF THE RUMEN AND RETICULUM, WITH THE ŒSOPHAGEAL FURROW.

A, Left sac of the rumen; B, anterior extremity of that sac turned back on the right sac; C, its posterior extremity, or left conical pouch; G, section of the anterior pillar of the rumen; *g*, *g*, its two superior branches; H, posterior pillar of the same; *h*, *h*, *h*, its three inferior branches; I, cells of the reticulum; J, œsophageal furrow; K, œsophagus; L, abomasum.

the rumen a strong prolongation, directed backwards, and to the left; it is continued on the superior wall by two branches, which separate at an acute angle. The *posterior pillar* (Fig. 269, H), more voluminous than the preceding, has three branches at each of its extremities—a middle and two lateral. The middle branches are carried forwards on the limit of the two sacs, which they separate from one another; that from above meets the corresponding branch from the anterior pillar. The lateral branches diverge to the right and left in describing a curve, and in circumscribing the entrance to the conical cysts, which they transform into two compartments distinct from the middle portion of the sac of the rumen; the inferior go to meet the superior branches, but do not altogether join them.

The internal surface of the rumen is covered by a multitude of papillary prolongations, dependencies of the mucous membrane. To the right, and in the *culs-de-sac*, these papillæ are remarkable for their number, their enormous development, and their general foliated shape. On the left side they are more rare, particularly on the superior wall, and only form very small mammiform tubercles; they are absent on the muscular columns. This papillary arrangement is still more developed in certain wild Ruminants, and it is scarcely possible to give an idea of their richness in the stomach of Gazelles.

The interior of the rumen offers for study two openings, situated at the anterior extremity of the left sac: one is the œsophageal orifice, pierced in the superior wall, dilated into an infundibulum, and prolonged into the small curvature of the reticulum by a particular furrow (or channel), which will be described after the latter compartment; the other, placed below, and opposite the preceding, traverses the bottom of the *cul-de-sac* from before to behind, and forms the communication between the paunch and reticulum: it is a very large opening, circumscribed below and on the sides by a septum or semilunar valve, resulting from the junction of the parietes of the rumen with those of the reticulum.

Structure.—Like all the hollow organs in the abdomen, the rumen has three tunics: a *serous*, a *muscular*, and a *mucous*.

The *serous* envelops the organ throughout, except above, in front, and to the left, the point which touches the sublumbar region, and the pillars of the diaphragm, as well as the bottom of the notches which separate the *culs-de-sac* from the extremities. This membrane gives origin, like that of the stomach of the Horse, to a vast duplicature—the great omentum. The arrangement of this, which is somewhat difficult to observe in the **Ox**, in consequence of the enormous weight of the gastric mass, is readily seen in the smaller Ruminants. It begins at the middle of the faces of the paunch and the fissure intermediate to the two conical cysts, forming a wide envelope that contains the right sac and the abomasum; it becomes attached in passing over the great curvature of the last-named cavity, and is confounded, superiorly and posteriorly, with the great mesentery.

The *muscular coat* is very thick, and forms the internal columns of the viscus. Its fibres are disposed in several layers, whose arrangement is simple, and offers nothing really interesting to study, except in the points where the serous tunic passes from one *cul-de-sac* to another, or from the rumen to the reticulum; there it is often accompanied by thin and wide muscular fasciculi which, like the latter membrane, stretch over the intermediate fissures, and thus become real unitive or common fibres.

The muscular fibres of the rumen present an unmistakable transverse striation—a very rare physical characteristic in the muscular tissue of organic life.

The *mucous membrane* offers some peculiarities, which deserve a few words. The *corium* is very thick, and probably contains some glands, but they must be extremely few. The free face of the membrane is excessively uneven, in consequence of the papillary apparatus mentioned above.

The *papillæ* of the rumen are foliaceous, conical, fungiform. Those of the first description are much more numerous than the others; they have the shape of an oval, elongated leaf; their summit is wide and rounded, and the base narrow and apparently implanted in the corium. On one face is a little rib that springs from the base and disappears on the widened portion, resembling the principal vein or nervule of a leaf. On the other face, opposite the vein, is a faint longitudinal groove.

These papillæ are constituted by a layer of nucleated connective tissue, covered by epithelium; the former, in the principal papillæ, has on its faces and extremities minute prolongations, resembling on a small scale the secondary papillæ described as existing on the lingual mucous membrane. In the centre of the papillæ are one or two main arteries, derived from the network of the corium. These pass, in a slightly flexuous manner, to the summit, and break up into several branchlets, succeeded by veins, that descend along the surface of the papilla into each of its secondary prolongations.

The conical and fungiform papillæ are few in the left sac, and resemble the papillæ of the same name described on the tongue.

The *epithelium* of the mucous membrane of the rumen is remarkable for its strength and cohesiveness. It belongs to the category of stratified tesselated epithelium, and forms a sheath to each papilla, covering the corium in the interpapillary spaces.

There are frequently found, in opening the rumen of animals just killed, large exfoliated patches on the surface of this layer. This is a sufficient indication of the activity of the secretion of the epithelium, and the rapidity of its renovation.

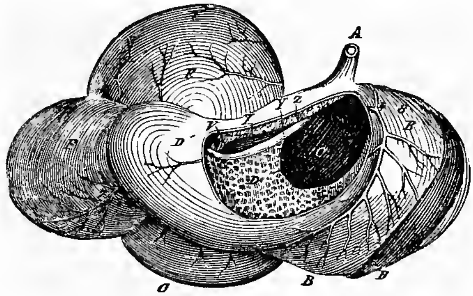
Reticulum (Honeycomb) (Figs. 268, 269, 270). *Situation—Form—Relations.*—This, the smallest compartment, is elongated from side to side, slightly curved on itself, and placed transversely between the posterior face of the diaphragm, in one direction, and the anterior extremity of the left sac of the rumen in the other; the latter only appearing, externally, to be a prolongation, or a diverticulum of the rumen.

It has *two faces*, *two curvatures*, and *two extremities*. The anterior face adheres to the tendinous centre of the diaphragm by connective tissue. The *posterior face* lies against the anterior extremity of the rumen. The *great inferior* or *convex curvature* occupies the supra-sternal region. The *lesser, superior*, or *concave curvature* partly corresponds to the lesser curvature of the omasum. The *left extremity* is only separated from the rumen by a fissure, which lodges the inferior artery of the reticulum. The *right extremity* forms a globular *cul-de-sac*, in relation with the base of the abomasum.

Interior (Figs. 269, 270).—The internal surface of the reticulum is divided by ridges of the mucous membrane into polyhedral cells, which, in their regular arrangement, look like a honeycomb; they are widest and deepest in the *cul-de-sac*, and become gradually smaller in approaching the superior curvature. The interior of these cells is divided into smaller spaces, included one within the other, by secondary and successively decreasing septa. The principal septa offer on their free border a series of conical prolongations, with a rough hard summit; while their faces are studded with minute, blunt, or pointed papillæ. The secondary septa also show similar prolongations; and those on their free margin are even more developed than on the chief septa. Lastly, from the bottom of the cells spring up a crowd of long, conical, and very pointed papillæ, resembling stalagmites in their arrangement.

It may be noted that the foreign bodies so frequently swallowed by Ruminants, are usually lodged in the reticulum; therefore it is that at the bottom of the cells are found either small stones, and needles or pins—often fixed in the intermediate septa—or nails, scraps of iron, etc. The interior of the reticulum communicates with the left sac of the rumen by the orifice already described, and with the omasum by a particular opening placed near the middle of the small curvature, though a little more to the right than the left. This opening—eight or ten times smaller than the preceding—is connected with the infundibulum of the cardia by a remarkable groove (or channel)—the *œsophageal*—which will be described separately, as it does not properly belong to the reticulum.

Fig. 270.



ANTERIOR VIEW OF THE OX'S STOMACH (THE ANTERIOR WALL OF THE RETICULUM HAS BEEN REMOVED TO SHOW THE ŒSOPHAGEAL GROOVE).

A, Œsophagus; B, left sac of the rumen; C, right sac; D, reticulum; D′, interior of ditto; E, omasum; F, abomasum; X, œsophageal groove; Y, its posterior lip; Z, its anterior lip; V, opening communicating with the reticulum and omasum; R, spleen; O, opening between the rumen and reticulum.

Structure.—The *serous membrane* does not cover all the anterior surface of the organ, as the latter adheres to the posterior face of the diaphragm. The *muscular tunic* is much thinner than that of the paunch, and more fasciculated. The fibres pass in the same direction. The *corium* of the *mucous membrane* sends a prolongation into each of the septa of the alveoli, and into each of the conical papillæ on these septa, or to the bottom of these alveoli. The stratified pavement epithelium is very thick, and its horny layer is very developed at the summit of the papillæ.

In the **Camel**, the *reticulum* does not form a compartment distinct from the rumen, and its existence is only indicated by some deep cells in the anterior part of that cavity. The entrance of the œsophagus into the rumen is oblique from left to right. The *œsophageal furrow* is limited by two unequal lips, the posterior being only slightly prominent, especially in its middle portion.

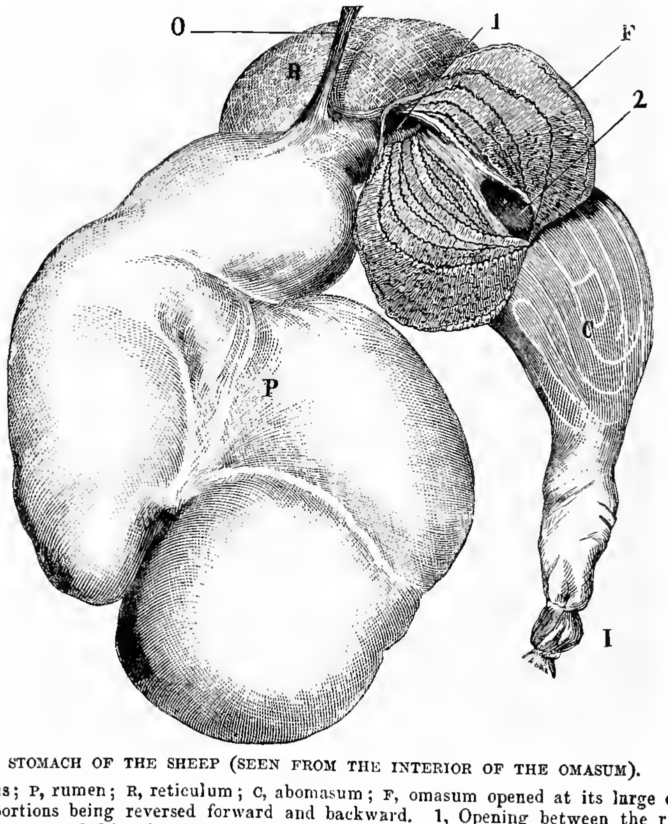
Œsophageal Groove (Figs. 268, 270, 271).—This furrow is so named because it appears to continue the œsophagus to the interior of the stomach. It extends on the lesser curvature of the reticulum from the cardia to the entrance of the omasum; commencing in the rumen, it belongs to the reticulum for the remainder of its extent. Measuring from six to eight inches in length, this demi-canal is directed from above downwards, and from left to right, between two movable lips, which are fixed by their adherent border to the superior wall of the reticulum. These two lips are thickened at their free margins, which look downwards and to the left. At their origin at the œsophageal infundibulum, they are thin and but slightly elevated; but they become thick and salient on arriving near the orifice of the omasum, which orifice they surround, though they neither meet nor become confounded with each other

The mucous membrane covering these two lips is much corrugated outwardly and on the free border; but in the interior of the groove it possesses all the characters of the œsophageal mucous membrane, in being smooth, white, and ridged longitudinally; near the orifice of the omasum it has some large conical papillæ.

If this membrane be removed to study the subjacent tissue, the following arrangement is observed: At the bottom of the channel, and in the space comprised between its two lips, are transverse muscular fibres, which belong to the rumen or reticulum. The lips themselves are entirely composed of longitudinal muscular fasciculi, particularly abundant towards the free border; these fasciculi are mixed with the proper fibres of the stomach, towards the extremities of the canal, and are carried from one lip to the other in forming loops around the orifices which communicate by this canal.

OMASUM (PSALTERIUM, MANY-PLIES, MANY-LEAVES, or MANYPLUS. Figs. 268, 270, 271).—In the **Ox,** this compartment is larger than the reticulum, but in the **Sheep** and **Goat** it is smaller,

Fig. 271.



STOMACH OF THE SHEEP (SEEN FROM THE INTERIOR OF THE OMASUM).

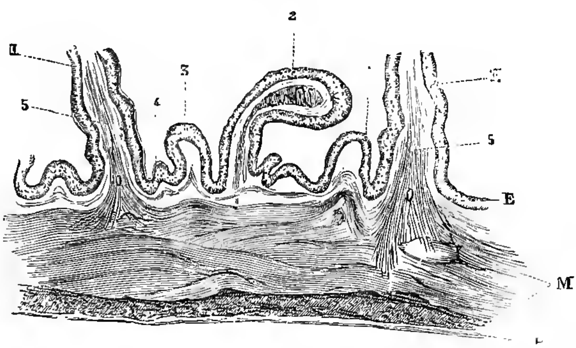
O, Œsophagus; P, rumen; R, reticulum; C, abomasum; F, omasum opened at its large curvature, the two portions being reversed forward and backward. 1, Opening between the rumen and reticulum, surrounded by the extremity of the lips of the œsophageal furrow; 2, opening between the omasum and abomasum. I, Commencement of the small intestine.

Situation—Form—Relations.—Situated above the *cul-de-sac* of the reticulum and the anterior extremity of the right sac of the rumen, this compartment, when distended, has an oval form, is slightly curved in an opposite direction to the honeycomb division, and depressed from before to behind. It has, therefore, an *anterior face*, applied against the diaphragm, to which it is sometimes attached by connective tissue; a *posterior face* lying towards the paunch: a *great curvature*, turned upwards, and fixed in the posterior fissure of the liver by an omental frænum which is continued on the lesser curvature of the abomasum and duodenum; a *lesser curvature*, which looks downwards and responds to the recticulum; a *left extremity*, exhibiting the *neck*, which corresponds to the orifice of communication between the reticulum and omasum;

a *right extremity*, continuous with the base of the abomasum, from which it is separated by a constriction analogous to that of the anterior extremity, but much less marked.

Interior.—This compartment shows, in its interior, the two apertures placed at its extremities. The right orifice, opening into the abomasum, is much wider than the left, which communicates with the reticulum. The cavity which these orifices bring into communication with the adjoining compartments, offers one of the most curious arrangements met with in the viscera; it being filled by unequally developed leaves of mucous membrane, which follow the length of the cavity. These leaves have an adherent border attached either to the great curvature or to the faces of the organ, and a free concave border turned towards the lesser curvature. They commence at the side of the orifice of the reticulum by denticulated ridges, between which are furrows, and which are prolonged from the base of the leaves to the entrance of the abomasum. At the latter aperture they disappear altogether, after rapidly diminishing in height. Their faces are studded by a multitude of very hard mamillary papillæ, resembling grains of millet, which are more developed and conical on some of the leaves than others. All these lamellar prolongations are far from being of the same extent; twelve to fifteen are so wide that their free border nearly reaches the lesser curvature of the viscus, and between these principal leaves are others which, though regularly enough arranged, are more or less narrower. At first there is remarked a secondary leaf, half the width of the chief ones,

Fig. 272.



SECTION OF THE WALL OF THE OMASUM OF THE SHEEP (FROM THE GREAT CURVATURE, SHOWING THE ORIGIN OF THE LEAVES).

P, peritoneum; M, the two musular layers; E, epithelium. 1, 1, Principal leaves at their origin; 2, secondary leaf; 3, 3, leaves of the third order; 4, denticulated lamina; 5, 5, two planes of muscular fibres ascending into the principal leaves, some issuing from the muscular layer of the organ.

between which it is placed; then, on each of its sides, another, one-half narrower; and, lastly, at the base of these, two denticulated laminæ more or less salient. In a general way, the leaves which are inserted into the great curvature are the longest and widest; and those attached to the faces of the viscus become shorter and narrower as they draw nearer the lesser curvature. The space comprised between these prolongations is always filled by very attenuated alimentary matters, which are usually impregnated by a very small quantity of fluid, but are also often dry, and sometimes even hardened into compact flakes.

Structure.—The *serous layer* is a dependency of the peritoneum, and offers nothing particular; it does not completely cover the anterior face.

The *muscular tunic* is much fasciculated, and thin. It is formed by two layers of fibres which do not pass in the same direction, and dependencies of this tunic pass into the substance of the leaves which fill the cavity of this compartment.

The *mucous membrane* is remarkable for the thickness of its stratified tesselated epithelium; all the leaves are formed by two layers of this membrane, laid one against the other; and as their structure is interesting, we will notice it.

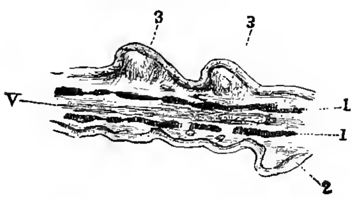
The principal leaves are composed of this duplicature of mucous membrane, and two layers of muscular fibres between; these layers are opposite each other at the commencement of the leaf, and separated by a transverse vessel; in the remainder of their extent they are kept apart by the vessels that pass towards the border of the leaf. Their fibres are detached from the surface of the muscular tunic and, at certain points, from its deep layer. In the smaller leaves there appears to be only one layer of muscular fibres; on all the leaves are various-sized papillæ, the smallest of which are like a grain of millet, and have for base a mass of condensed connective tissue, the superficial fibres of which form a kind of shell (Fig. 273); the largest are club-shaped. They receive blood-vessels, and we have found in the connective tissue which constitutes their basis, elements with a somewhat irregular outline, provided with nuclei, which we considered to be nerve-cells (Fig. 274).

The omasum in the Camel shows deep areolæ instead of leaves, and the opening with the abomasum is relatively very narrow.

Abomasum (Reed or Rennet. Figs. 268, 269, 270, 271). *Situation—Form—Relations.*—The abomasum stands next to the rumen for capacity. It is a pyriform reservoir, curved on itself, elongated from before to behind, and situated behind the omasum, above the right sac of the rumen. On the right it touches the diaphragm and the hypochondriac; on the left it is related to the rumen. The *greater curvature*, turned downwards, receives the insertion of the great omentum. The *lesser curvature*, inclined upwards, gives attachment to the serous band already noticed when speaking of the great curvature of the omasum. Its *base* is in contact with the *cul-de-sac* of the reticulum, and is separated from the omasum by the constriction in the form of a thick neck, which corresponds to the communicating orifice of the two stomachs. Its *point*, directed upwards and backwards, is continued by the duodenum.

Interior.—This being the true stomach of Ruminants, the mucous membrane lining its interior acquires all the characters which distinguish that of the stomach of the Carnivora, or that of the right sac of the Horse's stomach. It is soft, spongy, smooth to the touch, vascular, red-coloured, covered by a thin epithelium, and provided with numerous glands for

Fig. 273.



SECTION OF A LEAF OF THE OMASUM.

1, 1, Muscular planes; V, vessel; 2, epithelium; 3, 3, small-sized papillæ, round and hard.

Fig. 274.

LONGITUDINAL SECTION OF A LARGE PAPILLA FROM THE OMASUM, SHOWING NERVE-CELLS IN ITS INTERIOR.

the secretion of the gastric juice. Thinner than in monogastric animals, this tenuity is compensated for by a much greater extent of surface, which is still further increased by numerous lamellar folds. These latter are analogous in constitution to those of the omasum, cross in a very oblique manner the great axis of the abomasum, and altogether affect a kind of spiral arrangement.

The abomasum has two openings: one, situated at its base, opens into the omasum; the other, placed opposite to the first, and much narrower, is the pylorus, which is circumscribed, as in the other animals, by a muscular ring.

Structure.—The *serous membrane* is continuous with the omenta that abut on the great and lesser curvatures of the viscus. The *muscular layer* is of the same thickness as in the omasum. The *internal tunic* has already been noticed.

Functions of the Stomach in Ruminants.—We cannot pretend to give here a complete history of the phenomena of rumination, but must confine ourselves to describe in a few words what are the principal attributes of each gastric dilatation.

The *rumen* is a sac where the aliment taken during feeding-time is kept in reserve, and whence it is again carried into the mouth during rumination, after having been more or less softened.

The *reticulum* participates in the functions of the rumen, to which it is only a kind of diverticulum. But it is particularly with regard to liquids that it plays the part of a reservoir; the solid substances contained in it being always diluted by a large quantity of water.

The *œsophageal groove* carries into the omasum the substances swallowed a second time after rumination, or even those which the animal ingests in very small quantity for the first time.

The *omasum* completes the trituration and attenuation of the food, by pressing it between its leaves.

The *abomasum* acts as a true stomach, charged with the secretion of the gastric juice; in this reservoir occur the essential phenomena of gastric digestion.

COMPARISON OF THE STOMACH OF MAN WITH THAT OF ANIMALS

In its form, the stomach of Man much resembles that of the Carnivora.

The insertion of the œsophagus, however, does not offer so large an infundibulum. The organ is situated in the left hypochondriac, and is nearly horizontal.

Everywhere the mucous membrane is red and glandular; the muscular fibres are disposed in three planes, as in Solipeds, but the third is found only in the middle portion of the stomach, two alone being present towards the cardia and pylorus; where the stomach is largest the contractile tunic is thinnest.

The Intestines (Figs. 275 to 283).

The alimentary canal is continued from the stomach, in the abdominal cavity, by a long tube doubled on itself a great number of times, and which terminates at the posterior opening of the digestive apparatus. This tube is the *intestine*. Narrow and uniform in diameter in its anterior portion—which is named the *small intestine*—it is irregularly dilated and sacculated in its posterior part—the *large intestine*. These two portions of a whole, so markedly defined in all the domesticated Mammals, are but imperfectly distinguished from one another with regard to the digestive phenomena occurring in their interior. We will study them in all the animals which interest us, and conclude by a general and comparative examination of the entire abdominal portion of the digestive canal.

Preparation.—The study of the intestines does not demand, properly speaking, any special preparation; it being sufficient to incise the inferior wall of the abdomen to expose these viscera. As their mass, however, is heavy and unmanageable, it is advisable to expel their contents in a manner similar to that recommended for the preparation of the stomach: a puncture at the point of the cæcum allows the escape of the substances accumulated in that reservoir; those which fill the large colon may be removed by an incision made towards the pelvic curvature, and those in the floating colon by the rectum. The small intestine may be evacuated by three or four openings at about equal distances in the length of the viscus. Having done this, inflate the intestines to somewhat of their natural volume; this preparation then permits the general arrangement of the intestinal mass in the interior of the abdomen to be easily studied.

It would be well to remove the entire mass altogether from the body, and lay it out on a table, so as to isolate the various parts, study them in succession, and note their form.

In order to study the structure of a portion of the intestine, it should be treated as was the stomach—plunged into boiling water for a few minutes, then the serous and mucous membranes removed.

1. THE SMALL INTESTINE (Figs. 282, 283).

Length—Diameter.—The small intestine is a long tube, which, in a horse of ordinary height, may average about 24 yards in length, and from 1 to $1\frac{3}{4}$ inches in diameter. This diameter is susceptible of variation, according to the state of contraction of the muscular tunic of the viscus.

Form.—This tube is cylindrical, doubled on itself, and presents two curvatures—one *convex*, perfectly free; the other *concave*, named the *small curvature*, which serves as a point of insertion for the mesentery that sustains the organ. Removed from the abdominal cavity, freed from the serous folds which suspend it, and distended by air or water, this disposition of the small intestine naturally causes it to twist in a spiral manner.

Course and Relations.—The small intestine commences at the right *cul-de-sac* of the stomach, from which it is separated by the pyloric constriction. At its origin it presents a dilatation which, in form, closely simulates a small stomach, the curvatures of which are the inverse of those of the proper stomach. Placed at the posterior face of the liver, this expansion, or head, of the small intestine begins the narrower portion, which at first is directed forward, then bends suddenly backward—thus forming a loop investing the base of the cæcum on the right side; then it is carried to the left in crossing, transversely, the sub-lumbar region, behind the great mesenteric artery; here it is joined to the origin of the floating colon by a very short serous frænum. It then reaches the left flank, where it is lodged, and where it forms numerous folds that are freely suspended in the abdominal cavity among the convolutions of the small colon. The terminal portion of this conduit, which is easily recognized by the greater thickness of its walls and its smaller diameter, disengages itself from these convolutions to return to the right, and opens into the concavity of the cæcum, below, and a little to the inside of, the point where the large colon has its commencement.

In the language of the schools, this terminal portion is named the *ileum* (εἰλεῖν, "to twist"); the part which is suspended in the left flank, and which forms the principal mass of the intestine, is designated the *jejunum* (*jejunus*, "empty"); and the curvature formed by this viscus at its origin, from the pylorus to the great mesenteric artery, is termed the *duodenum* (twelve fingers' breadth).

This classical division is, however, altogether arbitrary, and scarcely deserves to be retained. It would be better to divide the intestine into a *fixed* or *duodenal*, and a *free* or *floating portion.*

Mode of attachment.—The small intestine is maintained in its position, at its extremities, by the stomach and the cæcum. But its principal means of fixation consists in a vast peritoneal fold, which, from its use, is named the *mesentery* (μέσον, ἔντερον, "mediate" or "middle").

This serous layer presents a very narrow anterior part which sustains the duodenum, and fixes it in such a manner as to prevent its experiencing any considerable displacement. Continuous, in front, with the gastro-hepatic omentum, this portion of the mesentery is successively detached from the base of the liver, the inferior aspect of the right kidney, or even from the external contour of the base of the cæcum, and, lastly, from the sublumbar region, to be soon confounded with the principal mesentery. This becomes wider as it approaches the cæcal extremity, and arises, as from a centre, from the outline of the great mesenteric artery, to spread in every direction, and is inserted into the small curvature of the floating portion of the viscus. The great length of this insertion causes it to become extended in a spiral or screw-like manner, around its point of origin. It may be remarked that the terminal extremity of the intestine is retained between the two serous layers of the mesentery, to a certain distance from its free border. This peritoneal fold consequently forms at this point—at the side opposite to its insertion into the intestinal tube—a particular frænum, which is observed to be carried to the anterior face of the cæcum.

Interior.—The interior of the small intestine shows longitudinal folds, which are effaced by distension, except towards the origin of the duodenal portion. Those met with in this situation possess all the characters of the *valvulæ conniventes* (*valves of Kerkring*) in Man; they resist traction on the intestinal membranes, and are formed by two mucous layers laid together, with a plentiful supply of connective tissue between them.

The internal surface of the small intestine also offers for study a multitude of villosities and glandular orifices, or follicles, which will be noticed hereafter. It communicates with the inner surface of the stomach by the pyloric orifice, and with that of the cæcum by means of an opening which projects into the interior of that reservoir, like a tap into a barrel. This projection, which is not very marked, is formed by a circular mucous fold, strengthened externally by muscular fibres, and is named the *ilio-cæcal valve* or *valvula Bauhini.* Two additional orifices open on the surface of the small intestine in its duodenal portion, from 5 to 8 inches from the pylorus: one is the orifice common to the biliary and principal pancreatic duct, the other that of the accessory pancreatic duct.

STRUCTURE.—The wall of the small intestine, like that of the other hollow viscera in the abdominal cavity, is composed of three tunics:—

1. *Serous membrane.*—This envelops the organ everywhere, except at its small curvature, which receives the insertion of the mesentery; it adheres closely to its surfaces and the great curvature.

2. *Muscular membrane.*—Covered internally by a layer of condensed connective tissue (which is sometimes considered a fourth tunic), this middle membrane has two planes of fibres—one, superficial, is formed of longitudinal fibres uniformly spread over the whole surface of the viscus; the other, deep, is composed of circular fibres, which are a continuation of those of the pyloric ring.

3. *Mucous membrane.*—This tunic, extremely interesting to study, is soft, spongy, highly vascular, very delicate, and of a reddish-yellow colour. Its external face is loosely adherent to the muscular membrane, and its free face exhibits the villi, and the glandular or follicular orifices already noticed.

It comprises, in its structure, an epithelial lining, and a mucous dermis or corium.

The *epithelial layer* is formed of a single row of spheroidal cells, implanted, by their summit, which is often ramifying, in the surface of the dermis, and lining the interior of the orifices which open on the inner face of the membrane. The base of these cells has an amorphous cushion, which, when they are all united, appears like a thin layer spread on the inner surface of the intestine. Their protoplasm is frequently fenestrated or reticulated (Renaut); and among the ordinary spheroidal cells, some calyciform cells are met with here and there.

The *mucous dermis* is thick and loose in its deeper portion, and is constituted by fasciculi of connective tissue, mixed with elastic fibres, and lymphoid elements. On its free surface it exhibits projections (*villosities*) and depressions (*follicles*), which correspond to the *glands.* It has a *muscular layer*, the unstriped fibres of which are arranged in a similar manner to those of the muscular coat of the intestine. Lastly, it contains follicles, and vascular and nervous networks. We will study each of these.

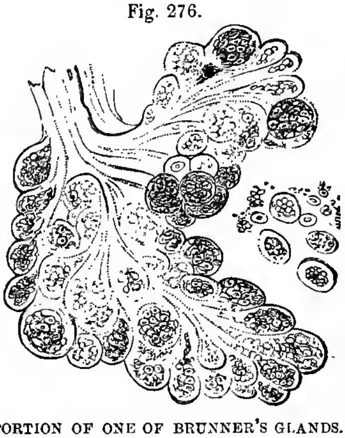
The *villi* are the foliated or conical appendages, which are found to be most developed in the shortest portion of the intestine. In Birds and the Carnivora they attain their maximum length; while in Ruminants they are in a rudimentary state, though, whatever may be their dimensions, they are always visible to the naked eye. Their number is considerable, and they have been justly compared to the pile of velvet. In structure, they are each formed by a small mass of connective tissue, in the centre of which is a chyliferous vessel or several vessels, with a magnificent network of peripheral capillary blood-vessels; the whole being enclosed in a complete epithelial sheath.

Fig. 275.

A. VILLI OF MAN, SHOWING THE BLOOD-VESSELS AND LACTEALS. B. VILLUS OF A SHEEP.

The *orifices* opening on the intestinal mucous membrane belong either to Brunner's (*duodenal*) glands, or to those of Leiberkühn (*simple follicles*).

Fig. 276.



PORTION OF ONE OF BRUNNER'S GLANDS.

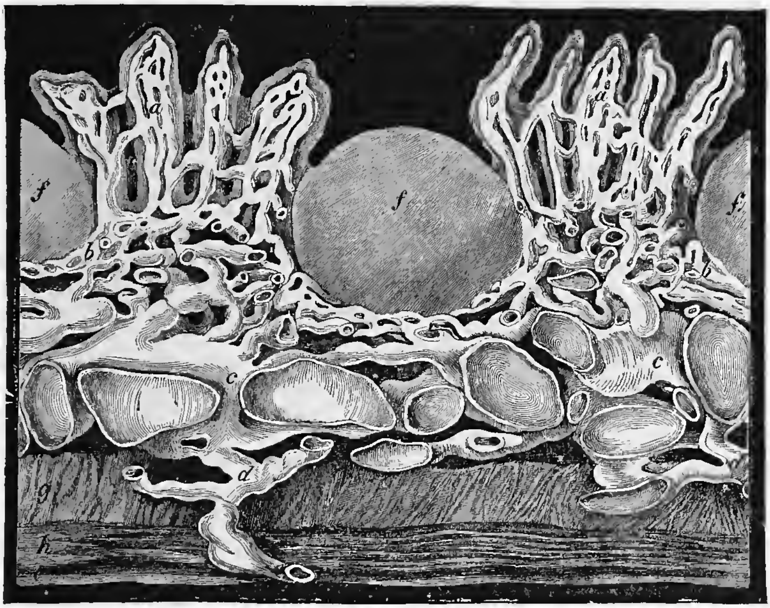
Brunner's glands form a continuous layer beneath the duodenal mucous membrane. They are tubular glands, ramifying and flexuous, which open on the surface of the mucous membrane, either by a special excretory canal, or through the medium of a Lieberkühn's gland. (These glands secrete a clear alkaline mucus, which contains no formed elements, such as cells or nuclei.)

The *glands* (*cryptæ mucosæ*) *of Lieberkühn* or *Galeati* are placed in the substance of the mucous membrane, and are distinguished by their microscopical dimensions, their considerable number, and their tubular form, which has caused each of them to be compared to the finger of a glove; they are implanted perpendicularly in the membrane, and open on its free surface. They are found throughout the whole extent of the intestine, and are lined with spheroidal epithelium.

The *solitary glands* or *follicles* (*glandulæ solitariæ*, or *lenticular glands*) are round, salient bodies, visible to the naked eye. They are somewhat rare in the small intestine, but are more abundant at the posterior portion of the large intestine. They are formed by a mass of lymphoid elements, enveloped in some condensed fasciculi of connective tissue. Around them the mucous membrane is slightly umbilicated, and is destitute of villa and tubular glands, though these are arranged in a circle around the follicles, to form the *coronæ tubulorum*. (The solitary glands usually contain a cream-like secretion, which covers the villi on their free surface.)

The *aggregated follicles* (*glandulæ agminatæ*) are nothing more than solitary glands collected together in a limited space, where they constitute what are

Fig. 277.



PERPENDICULAR SECTION THROUGH ONE OF PEYER'S PATCHES IN THE LOWER PART OF THE ILEUM OF THE SHEEP.

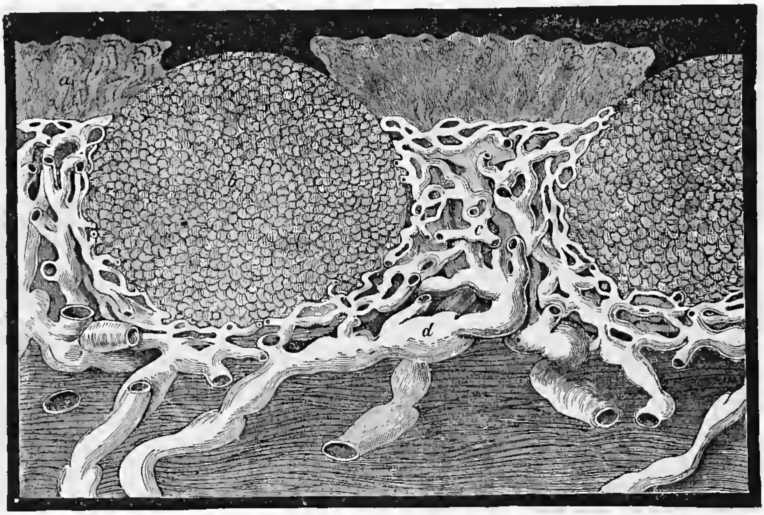
a, a, Lacteal vessels in the villi; *b, b*, superficial layer of the lacteal vessels (*rete angustum*); *c, c*, deep layer of the lacteals (*rete amplum*); *d, d*, efferent vessels provided with valves; *e*, Lieberkühn's glands; *f*, Peyer's glands; *g*, circular muscular layer of the wall of intestine; *h*, longitudinal layer; *i*, peritoneal layer.

known as the *glands of Peyer* or of *Pecklin*, *Peyer's patches*, or the *honeycomb glands*. Absent in the duodenum, and even at the commencement of the jejunum, these glands are about a hundred in number, and are very irregularly placed on the internal surface of the intestine at its great curvature, on the side opposite to the mesentery. Their form is oval or circular, and the smallest scarcely measure more than some few hundredths of an inch square, while the diameter of the largest increases to 1½ inch.

(Each of these patches is composed of a group of small, round, whitish vesicles, covered with mucous membrane; these vesicles consist of a moderately thick external capsule, having no excretory canal, and containing a similar secretion to that in the solitary follicles. They are surrounded by a zone or band of simple follicles, and the spaces between them are covered with villi.

The vesicles are usually closed; though it is supposed they open at intervals to discharge their secretion. The mucous and submucous coats of the intestine are intimately adherent and highly vascular, opposite the Peyerian glands.)

Fig. 278.



PERPENDICULAR SECTION THROUGH THE INTESTINAL WALL TO SHOW A SOLITARY FOLLICLE. *a*, Lieberkühnian glands; *b*, solitary follicle; *c*, lacteal vessels surrounding, but not penetrating, the follicles; *d*, large efferent vessels, provided with valves.

4. *Vessels and nerves.*—The small intestine receives its arteries almost exclusively from the *great mesenteric artery*. One, which goes to the duodenum, comes from the cœliac trunk. These arteries form a submucous network, from which branches pass inwards and outwards, the first to the muscular and serous tunics, the second to the glands and the villi. A tubular network surrounds each Lieberkühnian gland, and is observed in each villus; while a spherical reticulation surrounds each solitary follicle, loops being given off which penetrate nearly to the centre of the follicle.

Fig. 279.

VILLI OF INTESTINE, WITH THEIR CAPILLARY PLEXUS INJECTED.

The *veins* have the same arrangement, and finally enter the vena portæ.

The *lymphatics* constitute three superposed networks in the mucous membrane. The first is situated around the glandular orifices; it receives the central lacteal from each villus; the second is placed between the glandular and the muscular layer of the mucous membrane; the third lies in the deep portion of the membrane, and communicates with the meshes encircling the solitary glands. The largest emergent vessels from these three networks pass through the wall of the intestine, accompanying the blood-vessels between the layers of the mesentery, enter the mesenteric glands, and terminate in the reservoir of Pecquet (*receptaculum chyli*). There is another lymphatic network in the muscular tunic of the intestine.

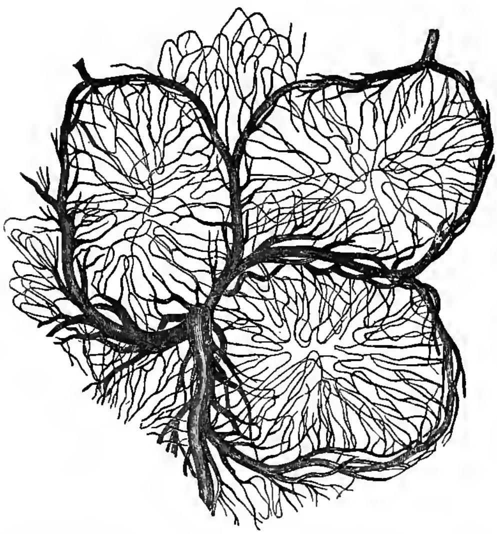
The *nerves* are from the solar plexus; they form a submucous plexus (*Meissner's plexus*) and a *myenteric plexus* (*Auerbach's plexus*), comprised between the two planes of the muscular tunic.

Numerous microscopic ganglia are found on the course of these plexuses.

DEVELOPMENT.—The small intestine appears at an early period in the fœtus, and during the fœtal existence of Ruminants preserves a very remarkable predominance over the large intestine—a predominance equally marked in the vessels it receives; for in a fœtus of five months, we have found the collective arteries of the small intestine equivalent to about ten times the volume of those of the cæcum and colon.

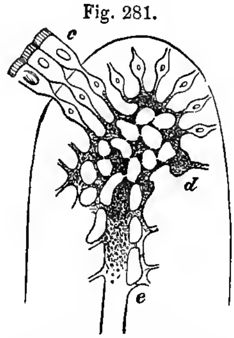
FUNCTIONS.—It is in the small intestine—under the influence of the hepatic, pancreatic, and intestinal secretions—that are carried on those transformations

Fig. 280.



HORIZONTAL SECTION THROUGH THE MIDDLE PLANE OF THREE PEYERIAN GLANDS, SHOWING THE DISTRIBUTION OF THE BLOOD-VESSELS IN THEIR INTERIOR.

Fig. 281.



DIAGRAMMATIC REPRESENTATION OF THE ORIGIN OF THE LACTEALS IN A VILLUS.

e, Central lacteal; *d*, connective-tissue corpuscles with communicating branches; *c*, ciliated columnar epithelial cells, the attached extremities of which are directly contiguous with the connective tissue corpuscles.

that constitute the digestive function. It is also in this intestine that the absorption of the nutritive principles and fluids commences, and in which the villi are the essential organs.

2. The Large Intestine.

The large intestine commences by a vast reservoir in the form of a *cul-de-sac*, named the *cœcum*. It is continued by the *colon*, the posterior extremity of which is succeeded by the *rectum*. It is separated from the small intestine by the *ileo-cœcal valve*.

A. Cæcum (Cæcum Caput Coli) (Figs. 282, 283).

Situation—Direction.—This is a very wide and elongated sac, occupying the right hypochondriac, where it affects an oblique direction downwards and backwards.

33

Dimensions—Capacity.—Its length is ordinarily a little over three feet, and it will contain, on an average, about 7½ gallons of fluid.

Form—External surface.—The elongated sac formed by the cæcum is conical in shape, terminating in a point inferiorly, and bulging and curved like a crook superiorly. Externally, it exhibits a great number of circular furrows, interrupted by longitudinal muscular bands, four of which are observed in the middle portion of the organ; they disappear towards its extremities. The bottom of these furrows necessarily corresponds to the internal ridges, and these can be made to disappear by destroying the longitudinal bands, which considerably lengthens the cæcum; thus showing that these transverse puckerings are due to the presence of the riband-like cords, and have for their object the shortening of the intestine without diminishing the extent of its surface.

Relations.—To study its relations, the cæcum is divided into three regions:—

1. The *superior extremity*, *base*, *arch*, or still better, the *crook*, shows in the concavity of its curvature, which is turned forwards, the insertion of the small intestine and origin of the colon. Placed in the sublumbar region, it is related, superiorly, to the right kidney and the pancreas, through the medium of an abundant supply of connective tissue. Outwardly, it touches the parietes of the right flank, and is encircled by the duodenum. On the inner side, it adheres by connective tissue to the termination of the large colon, and is in contact with the convolutions of the small intestine.

2. The *middle portion* is in contact, inwardly, with the same convolutions and the large colon; outwardly, with the cartilages of the false ribs, in following their curvature.

3. The *inferior extremity*, or *point*, usually rests on the abdominal prolongation of the sternum; but as it is free and can move about in every direction, it often happens that it is displaced from this situation.

Mode of attachment.—The cæcum is fixed to the sublumbar region and the terminal extremity of the large colon, by a wide adherent surface. All around this surface, the peritoneum—which constitutes the serous covering of the cæcum—is gathered into folds, and in passing from the cæcum to the origin of the colon, this membrane forms a particular short and narrow frænum, designated the *meso-cæcum*.

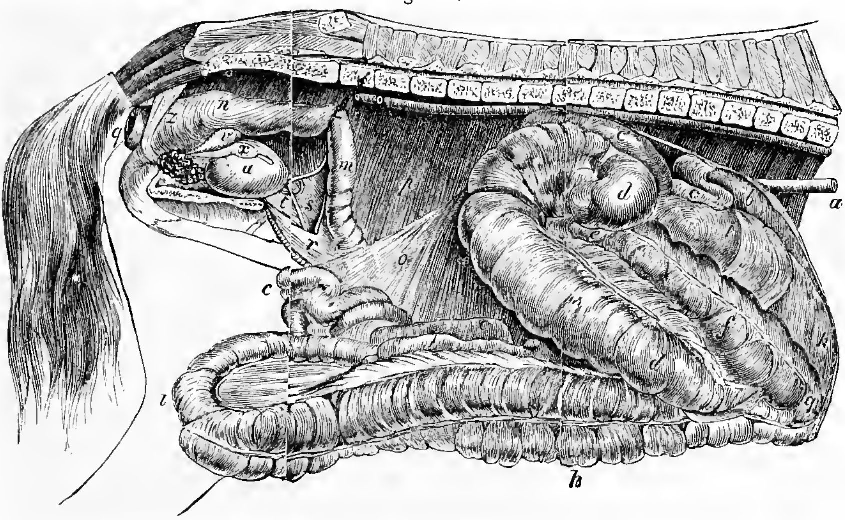
Interior.—Viewed internally, the cæcum offers for study the *valvulæ*, or transverse ridges corresponding to the external furrows. We have already seen that these are due to simple circular folds, comprising in their thickness the three tunics of the organ, and that they can be effaced by distension, to reappear afterwards in varying number and position—differing widely, in this respect, from the *valvulæ conniventes* of the small intestine.

Two orifices, placed one above the other, open on the internal surface of the cæcum, at the point corresponding to the concavity of the crook. The most inferior represents the terminal opening of the small intestine at the centre of the *ilio-cæcal valve*, the presence of which in the domesticated animals has, in consequence of a wrong appreciation of analogies, been denied; it is nothing more than the projection described as being made by the terminal portion of the small intestine. The second opening, placed about 1½ or 2 inches above the preceding, and puckered around its margin, establishes a communication between this viscus and the colon. If this opening be compared with the capacity of the canal that begins from it, it will be remarked that it could scarcely be narrower.

Structure.—The *serous tunic* does not call for any notice, beyond that already given when speaking of the attachments proper to the cæcum. The *muscular tunic* is formed of circular fibres, crossed externally by longitudinal bands, which maintain the organ in transverse folds. The *mucous membrane* is thicker than that of the small intestine, and is also distinguished from it by the absence of the *Brunnerian* and *agminated glands*. It has, however, the *solitary follicles* and *crypts of Lieberkühn*, as well as some few intestinal villi. The *blood-vessels* are the *cæcal arteries* and *veins*. The *lymphatics* pass to the sublumbar receptacle ; the *nerves* are derived from the great mesenteric plexus.

FUNCTIONS.—The cæcum serves as a reservoir for the enormous quantities of fluid ingested by herbivorous animals. The greater part of this fluid in its rapid

Fig. 282.



GENERAL VIEW OF THE INTESTINES OF THE HORSE (SEEN FROM THE RIGHT SIDE, WITH THE PELVIC FLEXURE AND A PORTION OF THE SMALL INTESTINE CARRIED BEYOND THE ABDOMINAL CAVITY).

a, Œsophagus; *b*, right sac of the stomach ; *c*, small intestine, showing its origin or duodenal portion, encircling the base of the cæcum ; *d*, cæcum ; *e*, origin of the large colon ; *f*, first portion of the large colon ; *g*, supra-sternal flexure ; *h*, second portion of the large colon ; *i*, pelvic flexure; *j*, third portion of the large colon ; *k*, diaphragmatic flexure ; *l*, fourth portion of the large colon ; *m*, termination of the free colon ; *n*, rectum ; o, mesentery proper ; *p*, colic mesentery (meso-colon) ; *q*, anus ; *r*, internal inguinal ring ; *s*, spermatic vessels ; *t*, deferent canal ; *u*, bladder ; *v*, vesiculæ seminales ; *x*, pelvic enlargement of the vas deferens ; *y*, prostate ; *z*, suspensory ligament of the penis.

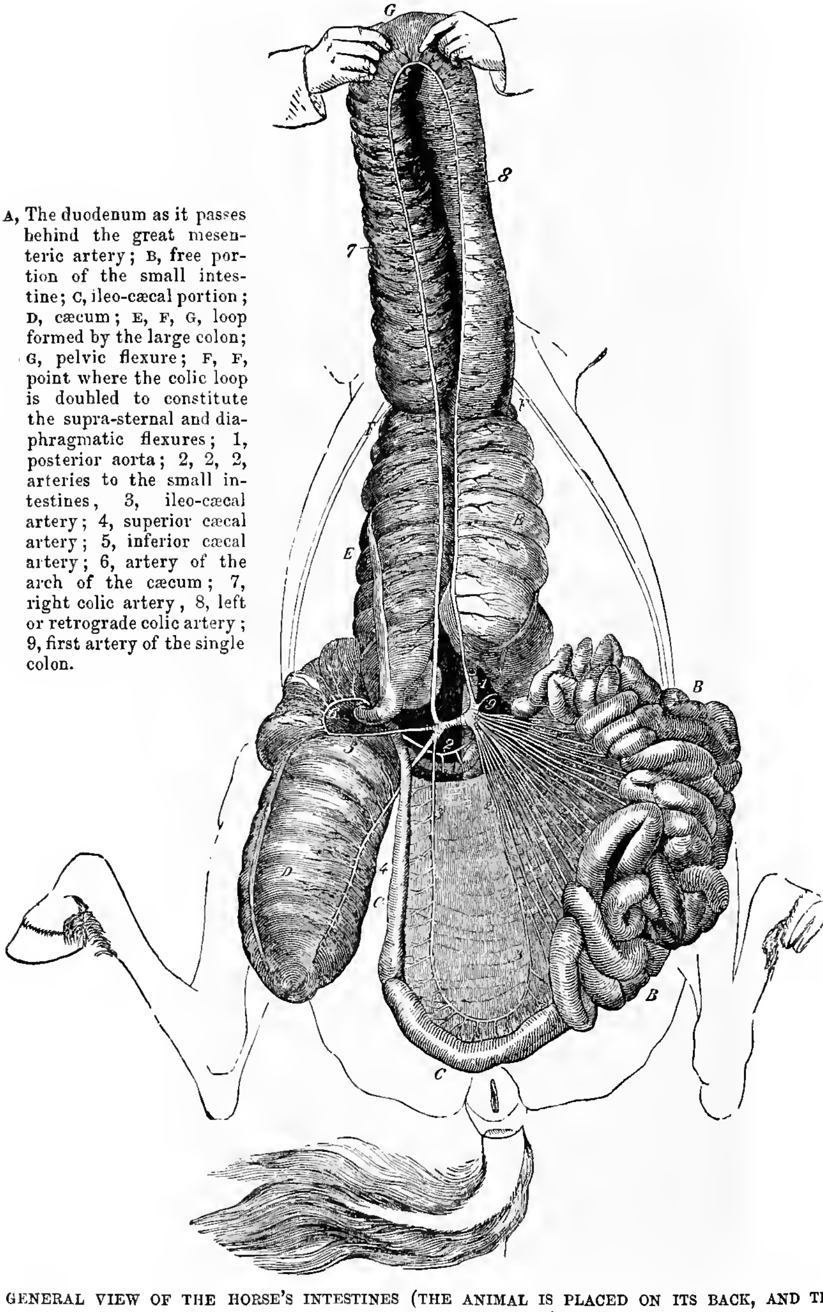
passage through the stomach and small intestine, escapes the absorbent action of the villi and accumulates in the cæcum, into which it may be said to wash the alimentary mass it comes in contact with ; it thus dissolves the soluble and assimilable matters this mass may yet contain, and so favours their entrance into the circulation, through the immense absorbing surface formed by the mucous membrane of the large intestine.

The aliment undergoes still further change, and digestion is completed in this viscus, principally in the Herbivora.

B. COLON.

The colon is divided into two portions, which differ from each other in volume, and in the disposition they affect in the abdominal cavity. The first is the *large* or *double colon;* the second, the *small, single,* or *floating colon.*

Fig. 283.



A, The duodenum as it passes behind the great mesenteric artery; B, free portion of the small intestine; C, ileo-cæcal portion; D, cæcum; E, F, G, loop formed by the large colon; G, pelvic flexure; F, F, point where the colic loop is doubled to constitute the supra-sternal and diaphragmatic flexures; 1, posterior aorta; 2, 2, 2, arteries to the small intestines, 3, ileo-cæcal artery; 4, superior cæcal artery; 5, inferior cæcal artery; 6, artery of the arch of the cæcum; 7, right colic artery, 8, left or retrograde colic artery; 9, first artery of the single colon.

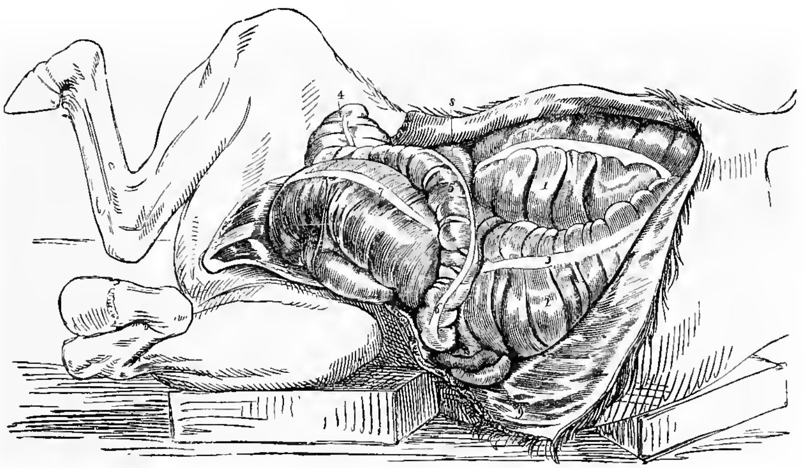
GENERAL VIEW OF THE HORSE'S INTESTINES (THE ANIMAL IS PLACED ON ITS BACK, AND THE INTESTINAL MASS SPREAD OUT).

The Large or Double Colon (Figs. 282, 283, 284).—This intestine begins at the cæcum, and terminates by suddenly contracting at the origin of the small colon.

Length—Capacity.—It is from about 10 to 13 feet in length, and has a medium capacity equal to 18 gallons.

Form—General arrangement.—Removed from the abdominal cavity, and extended on a table or on the ground, this portion of the intestine appears as a voluminous canal, offering a succession of dilatations and contractions; its surface being traversed by longitudinal bands, and sacculated and furrowed transversely for a great part of its extent, exactly like the cæcum. It is also doubled in such a manner as to form a loop, the two branches of which are of equal length, and are held together by the peritoneum, which is carried from

Fig. 284.



THE COLON OF THE HORSE.

1, First portion ascending to form the supra-sternal flexure; 2, second portion descending to form the pelvic flexure, 7; 3, 6, longitudinal muscular bands; 4, point of the cæcum, 5; 8, duodenum; 9, small intestine.

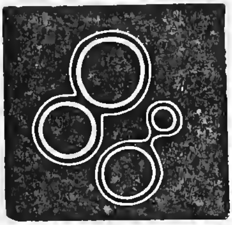
one to the other; so that the terminal extremity of the large colon returns towards the point of its origin.

But this colic flexure, owing to its length, could not be contained in the abdomen; and it is therefore doubled in its turn from above to below, and from right to left (at the points F, F, in Fig. 283), forming curvatures which will be noticed presently. From this circumstance, it results that the large colon, studied in the abdominal cavity, is divided into four portions lying beside each other in pairs; so that a transverse section of that cavity, made in front of the base of the cæcum, would give for this intestine the results indicated in Fig. 285.

Course and Relations.—In following the course of the large colon from its origin to its termination, in order to study its four portions in their normal relations, the following is observed :—

Commencing from the arch or crook of the cæcum, the colon is directed forwards, above the middle portion of that reservoir, which it follows to its point. Arrived at the posterior face of the diaphragm at its most declivitous part, it bends downwards and to the left, forming its first *sternal* or *supra-sternal flexure*, because it rests on the xiphoid cartilage of the sternum (Fig. 282, *g*). Here begins the second portion of the viscus, which is in immediate contact with the inferior abdominal wall, and extends backwards into the pelvic cavity, where it is inflected to the left to constitute the *sigmoid* or *pelvic flexure.* This curvature—the centre of the colic loop—is in relation with the rectum and bladder, as well as with the deferent canals, or the uterus and ovaries, according to the sex. It is succeeded by the third portion of the colon, which is carried forward, above, and to the left of the preceding. Bound to the second division by peritoneum and connective tissue, this new section reaches the tendinous centre of the diaphragm, and is then doubled upwards and to the right. The flexure arising from this third duplicature is called the *diaphragmatic,* because of its relations with the musculo-aponeurotic membrane that partitions the great cavity of the trunk, or the *gastro-hepatic curvature,* in consequence of its lying equally against the liver and stomach (it is also designated the *sigmoid flexure*) (Fig. 282, *k*). To this flexure succeeds the fourth and last portion of the large colon, bound to the first portion, as the second is to the third. This extends, posteriorly, to the base of the cæcum, where it terminates in a sudden contraction, and is continued by the small colon ; it occupies the sublumbar region, and, through the medium of connective tissue, is applied against the inferior face of the pancreas and the inner side of the cæcal arch.[1]

Fig. 285.



PLAN OF THE COLON.

Mode of attachment.—The large colon can be easily displaced in the abdominal cavity. It is nevertheless fixed : 1. By its origin, to the cæcum and to the serous frænum which attaches it to that receptacle. 2. By the adherence of its terminal portion to the pancreas and arch of the cæcum. 3. By the meso-colon. The latter ligament forms, in the concavity of the pelvic flexure, a kind of racket, the handle of which is prolonged to a short distance between the two branches of the colic flexure. Beyond this, these two branches are directly placed side by side.

External surface.—We have seen that the large colon does not offer the same diameter everywhere, and that it is sacculated, plicated, and traversed by longitudinal bands ; it is, however, important to study in detail this disposition of its external surface in each of the regions already named.

At its origin, the large colon is extremely narrow, and scarcely equal to the small intestine. But it soon dilates and assumes a considerable volume, which it preserves beyond the pelvic flexure. It then becomes progressively constricted to the middle of its third portion, where the diameter, reduced to its minimum, is yet much greater than at the origin of the first portion. Near the diaphragmatic flexure, it is again gradually dilated, and finishes by acquiring, near its termination, the greatest volume it has yet exhibited. The muscular bands which maintain its transverse folds throughout the whole extent of its first dilated portion, are four in number. Three disappear in arriving towards the pelvic curvature, and the only one remaining is that which is placed in the concavity of that curvature. At the second dilatation there are three bands,

[1] We have, in some instances, found the large colon doubled on itself in an inverse sense—the second and third portions being placed above and in front of the first and fourth, with the pelvic flexure touching the sublumbar region, in front of the cæcum, and the point of the latter directed back towards the pelvis.

two of which are prolonged to the floating colon. The transverse folds formed by these flat bands are but faintly marked towards the pelvic curvature, and are altogether absent in the narrow portion succeeding it; it is only in the whole extent of the first dilatation that they are deepest and most numerous.

Internal surface.—This is exactly like that of the cæcum.

STRUCTURE.—The *serous membrane* envelops the whole of the colon, except in those places where it comes in contact with itself or with other viscera. So it happens that the peritoneum, in passing from the sublumbar region to the last portion of the colon, does not cover the surface, which adheres by connective tissue to the inferior aspect of the pancreas and cæcum; neither, in being carried from one branch of the colic flexure to the other, does it envelop their opposed sides, except at the pelvic flexure, where it forms the *meso-colon.*

The *muscular tunic* does not differ in its arrangement from that of the cæcum; neither does the *mucous membrane.* The *arteries* emanate from the great mesenteric; they are the *two colic arteries.* The two satellite *veins* soon form a single trunk, which enters the vena portæ. The *lymphatics* empty themselves into Pecquet's reservoir. The *nerves* emerge from the great mesenteric plexus.

THE SMALL, SINGLE, OR FLOATING COLON (Fig. 282).—This is a sacculated tube, which succeeds the large colon, and is terminated in the pelvic cavity by the rectum.

Length—Form—Course—Relations.—It is about 10 feet in length, and is arranged in a similar manner to the small intestine, except that it is double the size of that viscus, is regularly sacculated on its surface, and is provided with two wide and thick longitudinal bands, one on the side of its great, the other on its small, flexure. Arising from the terminal extremity of the large colon, to the left of the cæcum, where it is related to the termination of the duodenum, and where it receives the insertion of the great omentum, this intestine is lodged in the left flank, forming folds which are mixed with the convolutions of the small intestine. It afterwards passes into the pelvic cavity, to be directly continued by the rectum.

Mode of attachment.—Floating like the small intestine, the small colon is suspended by a serous layer, exactly similar to the mesentery proper, though wider, and named the *colic mesentery.* This mesentery is detached from the sublumbar region, not from around a central point, but from a line extending from the great mesenteric artery to the interior of the pelvic cavity. It is narrower at its extremities than in its central portion.

Interior.—The interior of the floating colon shows valvular folds, analogous to those of the cæcum and large colon. It is in the intervals between these that the fæcal matters are moulded into balls.

STRUCTURE.—The *serous membrane* is without special interest, and the *muscular tunic* is similar to that of the large colon. The *mucous membrane* is also the same. These membranes receive their blood by the *small*—and a branch of the *great—mesenteric artery.* A venous trunk, passing between the layers of peritoneum forming the mesentery, carries back the blood to the vena portæ. The *lymphatics* are nearly as fine and numerous as those of the small intestine; they enter the same confluent—the reservoir of Pecquet.

FUNCTIONS OF THE COLON.—In this intestine is accomplished the absorption of fluids, and of soluble alible matters. When the alimentary mass arrives in the small colon, deprived of its assimilable principles and charged with excretory substances thrown out on the surface of the intestinal tube, it loses its name and receives that of *excrement* or *fæces*. This excrement, compressed by the peristaltic contractions of the muscular tunic, is divided into little rounded or oval masses, which find their way to the rectum, where they accumulate, and whence, in due course, they are expelled.

C. RECTUM (Fig. 282).

The rectum extends, in a straight line, from the entrance to the pelvic cavity to the posterior opening of the digestive canal, or *anus*. It is nothing more, properly speaking, than the extremity of the small colon, the limit which separates them being somewhat arbitrary; it differs from that viscus, however, in having no bulgings, and in its walls being thicker and more dilatable; so that it can be distended into an elongated pouch, and form a reservoir or receptacle for the excrementitious matters until they are expelled.

Relations.—It is related, superiorly, to the roof formed by the os sacrum; inferiorly, to the bladder, the deferent canals, vesiculæ seminales, prostate gland, Cowper's glands, or to the vagina and uterus; laterally, to the sides of the pelvis.

Mode of attachment.—There ought to be considered as such: 1. The posterior extremity of the colic mesentery, representing the *meso-rectum*. 2. An orbicular fold, constituted by the peritoneum in its circular reflection around this viscus at the extremity of the pelvic cavity. 3. The suspensory ligaments of the penis, which, joining under the rectum, form a ring encircling the posterior extremity of the intestine (see Fig. 282 and the *description of the penis*). 4. A thick, triangular band, comprising two lateral parts, and composed of white muscular fibres; this band, which is really a prolongation of the muscular tunic of the viscus, is detached from the rectum above the anus, and is attached to the inferior aspect of the coccygeal bones, between the inferior sacro-coccygeal muscles, where its outline can be seen beneath the skin when the tail is elevated.

STRUCTURE.—The *serous membrane* does not envelop the whole of the rectum, that portion which traverses the bottom of the pelvic cavity being left uncovered by it. The *muscular layer* is very thick, and composed of large, longitudinal, and slightly spiral fasciculi, beneath which are annular fibres. The *mucous membrane*, loosely attached to the muscular tunic, shows longitudinal and transverse rugæ. The *small mesenteric* and the *internal pudic artery* (*artery of the bulb*) supply these membranes with blood. The nerves are derived from the *pelvic* or *hypogastric plexus*.

ANUS.—The anus, or posterior opening of the digestive tube, is situated at the posterior extremity of the rectum, under the base of the tail, where, in Solipeds, it can be seen forming a rounded prominence, which diminishes with age. It is at the border or margin of this orifice, which is corrugated like the mouth of a draw-purse where the intestinal mucous membrane meets with, and is continued by, the external skin.

In proceeding from within outwards, there are found the following elements entering into the structure of the anus: 1. The mucous membrane of the rectum. 2. The prolongation of the circular and longitudinal fibres of the muscular layer, forming what is named the *internal sphincter*. 3. A *sphincter muscle*, composed of red fibres, which receives the insertion of a *retractor*. 4. The fine, hairless, and closely attached skin, which covers the sphincter; though destitute of hair, it is rich in sebaceous follicles. We will only notice the muscles.

The **Sphincter of the Anus** (*sphincter ani*) is formed of circular fibres, some of which are fixed above, under the base of the tail, and are mixed, below, with the muscles of the perineal region, especially the posterior constrictor of the vulva in the female; in the male, these fibres are lost on the surface of the perineal aponeurosis. Comprised between the skin and the prolongation of the muscular layer of the rectum, this muscle is (during life), owing to its tonicity and natural shape, in a state of almost permanent contraction, in order to keep the anal aperture closed; it is only relaxed during the expulsion of fæcal matters or intestinal gases.

The **Retractor of the Anus,** or **Ischio-anal** muscle (*retractor ani*), is a wide band, attached to the internal surface of the sacro-sciatic ligament, and even to the supra-cotyloid crest, by aponeurotic fibres. The fasciculi composing this band are all parallel to each other, while their posterior extremities are insinuated beneath the sphincter, and are mixed with its fibres. This arrangement of the retractor ani clearly indicates that it pulls the anus forwards, re-establishing it in its normal position after expulsion of the fæces—an act that always results in carrying the posterior extremity of the rectum backwards.

These two muscles are of a red colour, and belong to those of animal life. Their *vessels* are derived from the same sources as those of the rectum. The *hæmorrhoidal nerve* supplies them both with filaments.

Differential Characters of the Intestines in the other Animals.

In the domesticated animals, the intestines vary as much in their dimensions, length, and diameter, as in their general arrangement.

1. The Intestines of the Rabbit (Fig. 286).

As for the stomach, so for the intestine we place the Rabbit immediately after Solipeds, because the analogies are more marked in them than in the other animals.

The *small intestine* does not show any dilatation at its commencement, but it has an enormous one at its termination in the cæcum, and which has in its interior a fine Peyer's patch; for this reason it is named the *glandular pouch.* The other agminated glands are equally very developed, and are remarkable for their thickness, though they are not numerous—being only seven or eight. They are easily seen through the thin wall of the intestine, when this has been washed and inflated. This intestine reaches the cæcum in passing before the first portion of the colon.

The *cæcum* is also proportionately more voluminous than in Solipeds. As in them, it has the shape of a cone suddenly attenuated towards its summit, and forming an arch or crook at its upper part; but this crook is not very distinctly separated from the colon, and is continuous with it, without showing any constriction. Its internal surface is very curious, as it is traversed by a spiral ridge of mucous membrane, which describes about twenty turns on the wall of the intestine, and ceases about 4 inches from the point. This layer—the presence of which is marked by a depression externally, that corresponds to its fixed border—may be about ⅓ of an inch or more in depth. The inferior *cul-de-sac* of the viscus, into which this fold does not enter, forms, like the termination of the small intestine, a veritable glandular pouch. The orifice of this latter intestine does not project into the interior of the cæcum; Bauhin's valve is a disc, pierced like the iris, and fixed by its larger circumference around the margin of that opening.

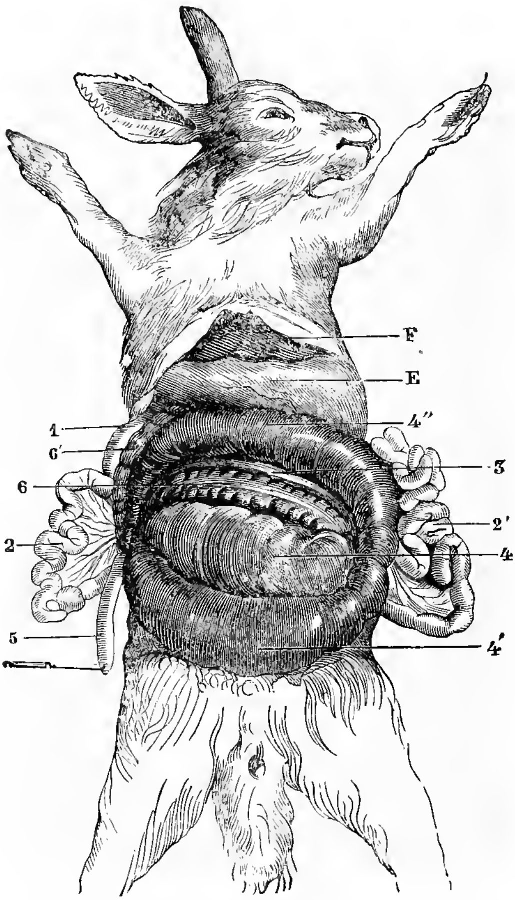
The *colon* also shows the division into two portions—the first, dilated and sacculated, and even provided with rudimentary longitudinal bands on its external surface—is covered internally by round and regularly arranged prominences which resemble thick villi, or traces of the valvulæ conniventes; the second, narrower and uniformly cylindrical, lies alongside the duodenum, ascends into the diaphragmatic region in company with that intestine, and terminates in the rectum, after describing several floating convolutions. On the sides of the rectum are two elongated glands which open into the perineal region.

The total length of the Rabbit's intestines is nearly twenty feet, of which the small intestine takes about ten feet.

2 THE INTESTINES OF RUMINANTS (Figs. 287, 288).

The small intestine of the **Ox** floats at the extremity of a broad mesenteric layer, which is narrower in front than behind, plane throughout, except at its intestinal border, which is of considerable length, and is folded into a multitude of festoons. Twice the length of the small intestine of the Horse—averaging about 49 yards—it is about one-half its diameter. The

Fig. 286.



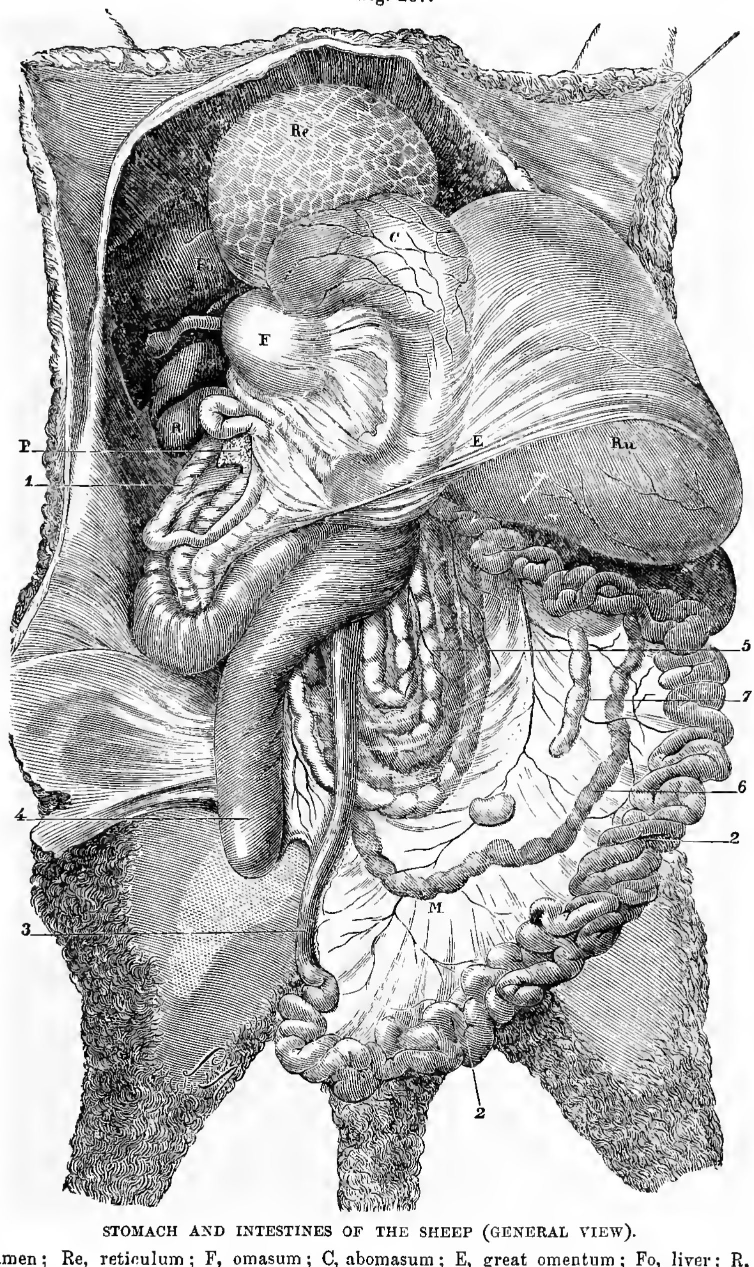
INTESTINES OF THE RABBIT (GENERAL VIEW).

F, Liver; E, stomach. 1, Duodenum; 2, 2′, jejunum; 3, ilium; 4, 4′, 4″, cæcum; 5, point of the cæcum (pushed to the right); 6, first portion of the colon; 6′, second portion of the colon.

duodenum, at first sustained by the omentum, which attaches the small curvature of the fourth compartment of the stomach to the posterior fissure of the liver, forms a particular loop, which is in contact with the sublumbar region before it goes to be suspended by the large mesentery, and to be continued by the convolutions of the floating portion. The ileum terminates as in the Horse. The Peyerian glands are less numerous on the internal surface of the small intestine than in Solipeds, though they are larger in size. In the **Sheep** and **Goat**, they are often more than eight inches in length, and extend to Bauhin's (ileo-cæcal) valve.

The *cæcum* is nearly cylindrical in form, without bulgings or longitudinal bands. The extremity of the *cul-de-sac*, rounded and globular, floats freely in the abdominal cavity, and is directed backwards. At its opposite extremity, the cæcum is continued directly with the

Fig. 287.



STOMACH AND INTESTINES OF THE SHEEP (GENERAL VIEW).

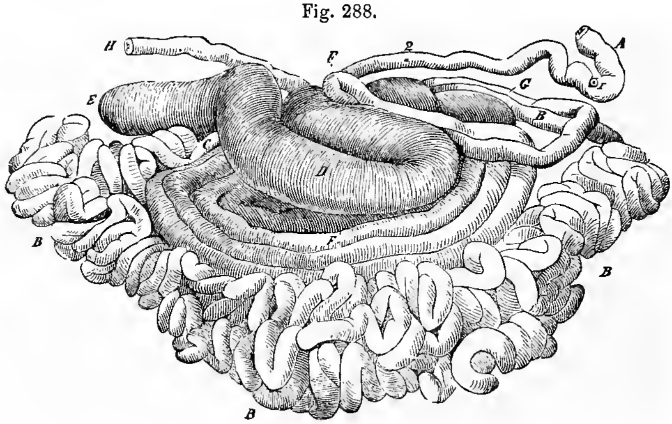
Ru, Rumen; Re, reticulum; F, omasum; C, abomasum; E, great omentum; Fo, liver; R, right kidney; P, right extremity of the pancreas; M, mesentery. 1, Duodenum; 2, floating portion of the small intestine; 3, terminal portion of the small intestine; 4, extremity of the *cul-de-sac* of the cæcum; 5, ellipsoid convolutions of the colon, seen through the right layer of the mesentery; 6, last turn of the double colon; 7, mesenteric glands.

colon, without forming an arch, after having received the insertion of the small intestine. In the **Ox**, in the vicinity of this insertion, there are traces of one of Peyer's patches. In the **Sheep** and **Goat**, these patches are very numerous.

The *colon*, sustained between the layers of the great mesentery, on the margin of which is suspended the small intestine, is coiled upon itself in such a way as to form a certain number of elliptical convolutions, by at first making several concentric spiral turns, which leave a certain interval between them for the reception of the eccentric convolutions. The last spiral turn is a little distant from the others; in the smaller Ruminants, it is close to the insertion of the mesentery in the small intestine, which it follows to near the duodenum, in describing regular festoons. On arriving near the trunk of the great mesenteric artery, this convolution passes to the right of that vessel, and is directed backwards, then forwards, thus forming a flexure, and turns back in company with the duodenal flexure. The colon then continues in a direct line to the rectum, attached to a short mesenteric layer, which, by its position, resembles the large suspensory band of the floating colon in Solipeds.

The calibre of this intestine is at first equal to that of the cæcum; but it soon becomes constricted, and maintains a uniform diameter, which scarcely exceeds that of the small

Fig. 288.



GENERAL VIEW OF THE INTESTINES OF THE OX (RIGHT FACE).

A, Origin of the duodenum; B, floating portion of the small intestine; C, termination of the small intestine; D, cæcum; E, its point directed backwards; F, flexure of the large colon at its termination; G, H, terminal portion of the intestine. 1, Insertion of the ductus choledochus; 2, insertion of the pancreatic duct.

intestine of the Horse. The muscular layer has the same arrangement as in the latter, although it is not covered in all its points by the serous tunic, in consequence of the situation of the colon between the two layers of the mesentery. In emaciated animals, however, it may be remarked that the serous covering furnished by these layers to the muscular coat of the colon is more extensive than at first we might be led to believe; on the left side, the prominences of the spiral convolutions are found to stand in relief on the surface of the mesentery, and it is therefore more completely enveloped in the corresponding peritoneal layer.

From this description, it will be seen that in the large intestine of the **Ox**, **Sheep**, and **Goat**, the *cæcal* division is well defined, but the division of the *colon* into a *large* or *double*, and a *small* or *floating portion*, can scarcely be made out; unless we regard as the large or flexured colon, the spiral folds contained between the layers of mesentery, and see the floating portion in the posterior extremity of the tube lying at first against the sublumbar wall of the abdomen, and afterwards suspended by the short mesenteric frænum which resembles the great colic mesentery of Solipeds. It is worthy of remark that the great mesenteric artery goes to the first, and the small mesenteric to the second portion, as in the Horse.

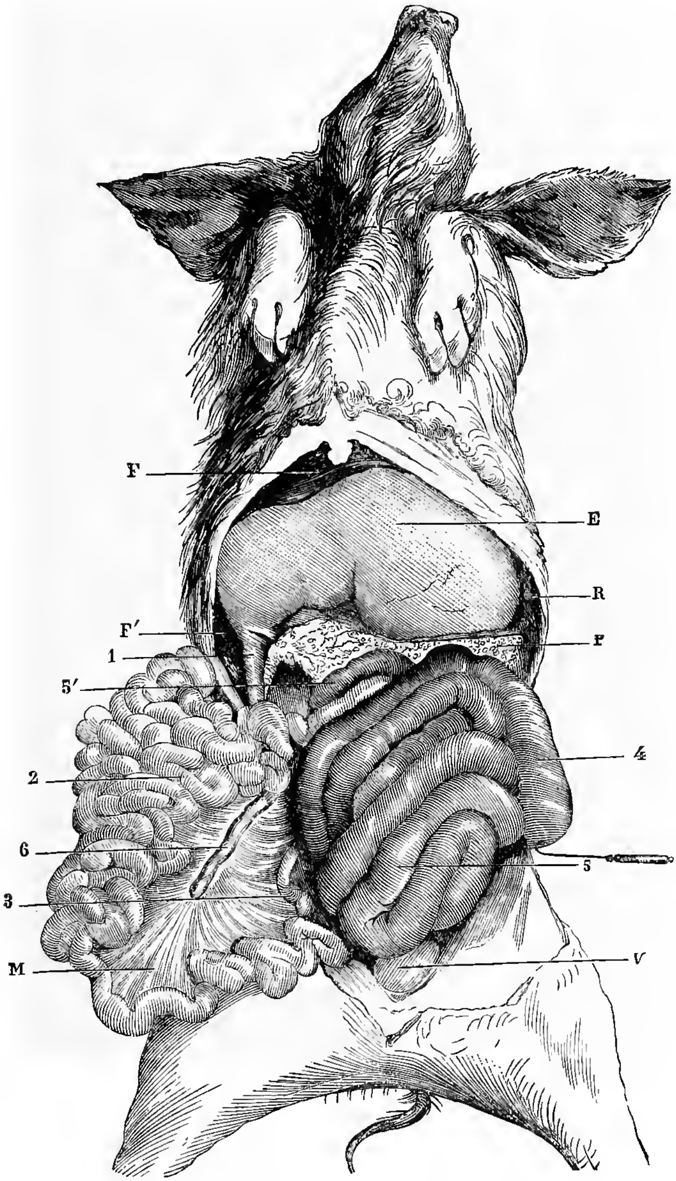
Measured throughout its whole extent, from the cæcal *cul-de-sac* to the anus, the large intestine of the **Ox** is from 33 to 39½ feet. It is, therefore, longer than that of the Horse; but its capacity is much less, for it does not exceed from 6½ to 7½ gallons.

3. The Intestines of the Pig.

The average length of the **Pig's** intestines is about 72 feet, of which 56 go to the small, and 16 to the large intestine.

In their general arrangement they bear some resemblance to those of the Ox. The *small intestine* is suspended from the border of a mesenteric layer, which contains an elongated mass of lymphatic glands. The *duodenum* forms an S curve in the convolutions of the colon. The

Fig. 289.



GENERAL VIEW OF THE INTESTINES OF THE PIG.

E, Stomach; F, F′, liver; P, pancreas; R, spleen; M, mesentery; V, bladder. 1, Duodenum; 2, jejunum; 3, origin of the ileum; 4, cæcum, the end of which has been turned to the left; 5, principal mass of the colon; 5′, last flexure of the colon emerging from the principal mass; 6, mesenteric gland.

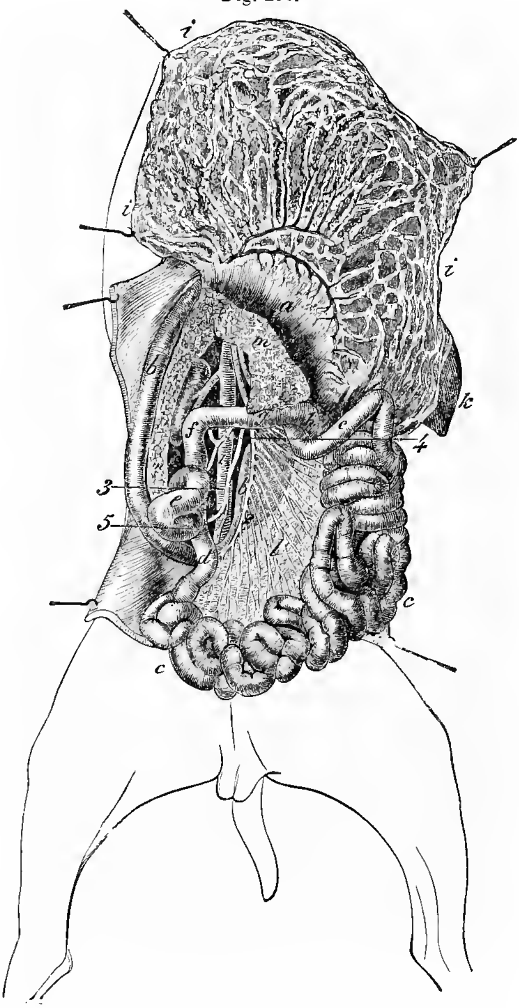
ileum occupies the posterior border of the mesentery, reaching the cæcum by keeping on the right of the colon; its insertion is oblique.

Among the peculiarities of the *small intestine*, may be cited the presence of an immense Peyerian gland, which occupies the latter portion of the canal, where it figures as a band measuring from 5 to 6½ feet in length.

The *cæcum* is directed backwards, and shows, on its internal surface, some Peyerian patches; it is sacculated, as in the Horse, and is furnished with three longitudinal bands. The *colon* is not comprised between the layers of the mesentery, except in its latter portion; for the remainder of its extent it is on the left side of the mesenteric layer, where it forms a distinct mass. It describes three turns from right to left, and three turns from left to right; it then passes forward, and, crossing again from right to left, insinuates itself between the duodenum and pancreas. It has two of these muscular bands in a portion of its track, and even three towards the cæcum.

The *rectum* is situated above the convolutions of the colon, at the border of a special mesenteric layer.

Fig. 290.



INTESTINES OF THE DOG.

a, Stomach; *b*, duodenum; *c*, jejunum; *d*, ileum; *e*, cæcum; *f*, ascending colon; *g*, transverse colon; *h*, origin of descending colon; *i*, great omentum; *k*, spleen; *l*, mesentery: *m*, pancreas. 1, Aorta; 2, great mesenteric artery; 3, artery of the duodenum; 4, artery of the large intestine; 5, small mesenteric artery.

4. The Intestines of Carnivora (Figs. 290, 291).

The intestines of the Carnivora are remarkable for their shortness and small volume. In a **Dog** of ordinary size, they scarcely measure more than 14 feet in length, of which only from 24 to 28 inches are for the large intestine. In the **Cat**, the latter is about one-half this length, and the entire extent of the viscus is equal to about 6 or 7 feet. With regard to capacity, Colin gives the following averages: for the Dog's small intestine, 1 quart; that of the Cat, ⅓ of a pint; for the large intestine in the Dog, nearly 1 quart, and in the Cat, a trifle more than ¼ of a pint.

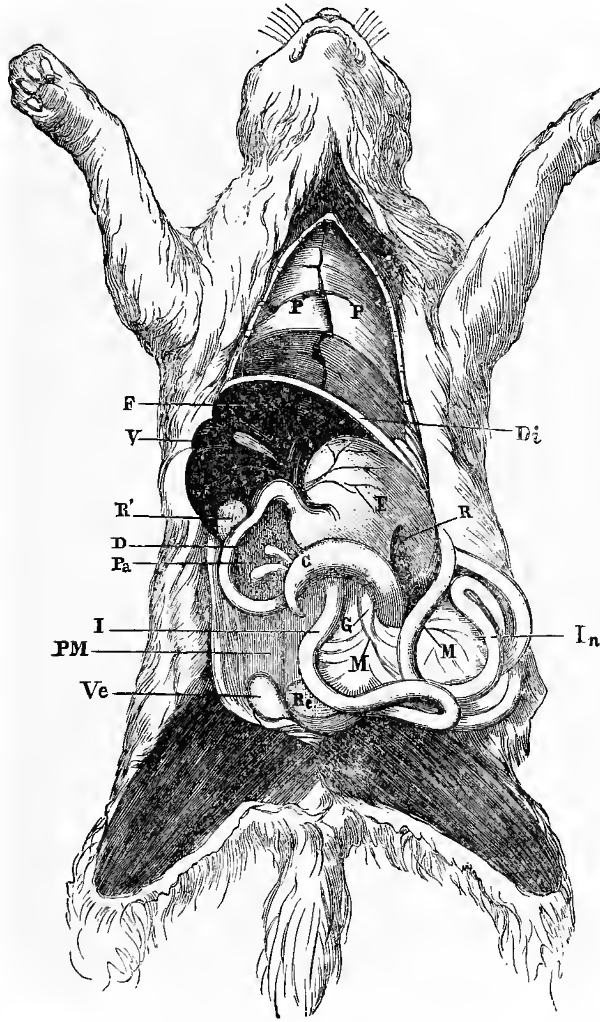
The *small intestine*, suspended at the extremity of a mesentery similar to that of Solipeds, rests on the inferior abdominal wall. It is distinguished by the thickness of its parietes, the length and number of its villi, which cover its inner surface, and which are even found accumulated on Peyer's patches. These latter number about 20 in the Dog, and 5 or 6 in the Cat.

The *cæcum* forms only a small, spirally twisted appendix, lined by a plicated and very follicular mucous membrane, particularly in the Cat, and shows at the bottom of the *cul-de-sac* a true Peyer's gland.

The *colon* is scarcely larger than the small intestine, and is neither sacculated nor furnished with longitudinal bands. In its short course, it is disposed somewhat like the same intestine in Man; and, as in him, it may be divided into the *ascending* (Fig. 290, *f*), *transverse* (*g*), and *descending colon* (*h*), which is continued directly by the rectum.

Near the anus, this latter viscus presents on its sides two narrow apertures leading to

Fig 291.



DIGESTIVE APPARATUS OF THE CAT.

F, Liver; V, gall-bladder; E, stomach; R, spleen; R′, right kidney; D, duodenum; Pa, pancreas; C, cæcum; In, small intestine (middle portion); I, ilium; M, M, mesentery; G, mesenteric glands; Re, rectum; Ve, bladder; Di, diaphragm; PM, sublumbar muscles; P, left lung; P′, right lung.

two glandular pouches, which are filled with a brownish matter that has a strong and fœtid odour, and is secreted by the glands covering the internal wall of these diverticuli.

(Measurements of the intestines, always a subject of interest to comparative anatomists, have been frequently made by different authorities. Leyh gives the length of the Horse's intestines as from 10 to 12 times that of its body; those of the Ox as from 20 to 22 times; the

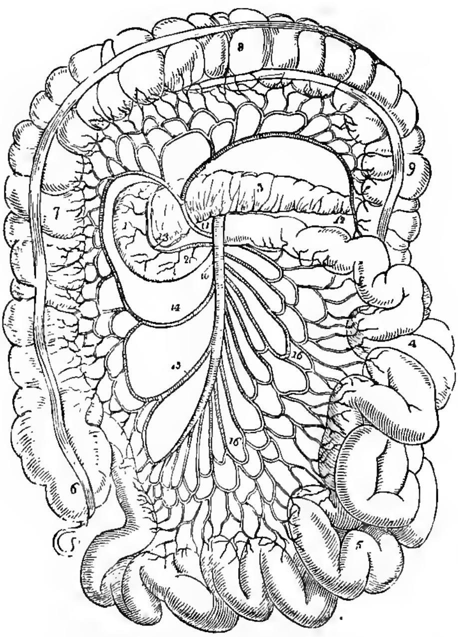
Sheep and Goat, from 26 to 28 times; the Pig, from 15 to 17 times; the Dog, from 4½ to 5½ times; and the Cat, from 4 to 5 times.

According to Hering, the entire length of the intestines of the Horse averages 100 Wurtemburg feet, 70 of which are for the small intestine, and 30 for the large. In the Ox they are 150 feet, 120 being for the small intestine, and 30 for the large; in the sheep they average 90 feet, from 65 to 70 being allowed for the small intestine; those of the Goat measure 95, the small intestine being 70; in the Pig they are 90 feet, 72 of which are for the small intestine, and 18 for the large; large-sized Dogs averaged from 23 to 27 feet, from 20 to 22 of which were for the small intestine; small dogs had only 6 feet in many instances. The Cat has from 4 to 5 feet.)

Comparison of the Intestines of Man with those of Animals.

Not unfrequently the *small intestine* of Man is divided into *duodenum* and *small intestine proper*. The *duodenum* is from 9 to 11 inches in length; is dilated at its origin, and firmly attached to the posterior face of the liver by a peritoneal fold, and to the right of the sublumbar region by connective tissue. It describes the arc of a circle, in the concavity of which is lodged the right extremity of the pancreas, and not the cæcum, as in Solipeds.

Fig. 292.



THE HUMAN INTESTINES AND SUPERIOR MESENTERIC ARTERY.

1, Descending portion of the duodenum; 2, transverse portion; 3, pancreas; 4, jejunum; 5, ileum; 6, cæcum and appendix vermiformis; 7, ascending colon; 8, transverse colon; 9, descending colon; 10, superior mesenteric artery; 11, colica media; 12, the branch that inosculates with the colica sinistra; 13, pancreatico-duodenalis inferior; 14, colica dextra; 15, ileo-colica; 16, 16, vasa intestinis tenuis.

The *small intestine proper* is suspended by a mesentery somewhat similar to that of the Horse. Its length varies much—from 13 to 26 feet. Its internal face has a large number of transverse rugæ, the *valvulæ conniventes.* It also shows from 20 to 25 Peyer's patches, particularly in the ileo-cæcal portion. Its structure is like that already described.

In the *large intestine* are recognized the cæcum, colon, and rectum.

The cæcum is a small reservoir placed in the right iliac fossa, a little obliquely downwards and to the left. It commences at the ileo-cæcal valve, has an average length of about 2½ inches, and terminates by a rounded extremity with a small hollow prolongation, averaging 3 inches in length—the *cæcal* or *vermiform appendix.* The mucous membrane is like that of animals, and the muscular tunic is the same.

The human *colon* is regularly sacculated, like the small colon of the Horse; it begins in the right iliac fossa, above the valvula Bauhini; it ascends to the lower face of the liver, passes abruptly across from right to left, and, arriving at the spleen, again changes its direction downwards to the iliac fossa; it then again describes the iliac S, to reach the mesial line, where it is continued by the rectum. From this course, the colon has been divided into three portions: the *ascending colon, transverse colon,* and *descending colon.* In the ascending and transverse colon are observed three series of sacculi, separated by three muscular longitudinal bands; the descending colon has only two.

There is scarcely anything special to note in the *rectum* and *anus*, except that they—and especially the latter—are very rich in arteries and varicose veins, and that the anus is separated from the rectum by small cavities open in front, and which are found in the Dog; these are the *sinuses of Morgagni.*

General and Comparative Survey of the Abdominal or Essential Portion of the Digestive Tube.

We have terminated the description of the anatomical characters which distinguish the essential portion of the alimentary canal in all the domesticated animals, and what gradations has this study revealed! Let us recapitulate and compare them, before showing the admirable harmony which pervades these diverse arrangements, and adapts them to the variations in general organization, habits, and instincts.

In the Carnivora, which subsist on flesh (*Dog* and *Cat*), we have seen a very ample stomach, secreting a gastric fluid throughout the whole extent of its mucous membrane, and intestines (relatively) extremely short.

In the Omnivora, or Mammalia which live on a mixed diet (*Pig*), we have found a small portion of the internal surface of the stomach occupied by a mucous membrane unfitted to secrete gastric juice, and the intestines relatively of much more considerable capacity than in Carnivora.

With the Herbivora, which derive their nourishment exclusively from the vegetable kingdom (*Ruminants*, *Rodents*, and *Solipeds*), the surface for the production of the gastric juice also singularly diminishes in extent, although the stomach in some of these animals is remarkable for its extraordinary development. But to compensate for this, the capacity of the intestinal canal assumes considerable proportions, and, in the various species, is in direct inverse relation to the area of the gastric surface. This surface being relatively more extensive in Ruminants than in the Rabbit, and more also in that animal than in Solipeds, all these animals ought to be classed in an inverse order, with regard to the development of the intestinal surface.

Finally, in considering as the internal surface of the stomach (a point of view quite rational) only those portions of the mucous membrane organized for the secretion of the gastric juice, we are led to recognize that this surface is in inverse proportion to that of the intestine; that it reaches its highest development in Carnivorous animals; and that it is reduced to the smallest dimensions in Solipeds—animals which, on the contrary, present a very great development of the intestinal surface.

The nature of the aliment readily accounts for these remarkable differences. The Carnivora, living on substantial food, take it in very large quantity, because they are exposed to frequent fastings; it is, therefore, necessary that they should have a stomach large enough to contain the ingested substances, and to secrete the amount of gastric juice needed to transform them into assimilable materials. If these animals have a short and narrow intestine, it is because a small surface only is required to absorb the products of digestion, these being mixed with but a minimum quantity of non-nutritive substances, and readily come in contact with the absorbing membrane.

With regard to the Herbivora, their food contains a trifling proportion of nutritive elements in an extremely large bulk of material, and being compelled to ingest great quantities at short intervals, the stomach, properly called, can only be a temporary receptacle for the aliment, which passes rapidly through it after being impregnated by the gastric juice. The surface which secretes that fluid is also singularly reduced, because if it has to perform its functions more frequently than in Carnivora, it is not required to display so much activity in a given time. If, on leaving the stomach, the alimentary matters encounter a vast intestinal surface, it is in order that the reparative materials dispersed in the alimentary mass may not escape the absorbent action of that surface, and may be the more effectually brought into contact with it. We have this exemplified in Ruminants; owing to their double mastication, and the triturating action of the omasum, their food arrives in the true stomach more comminuted and better attenuated than in the Horse; the mass, more finely broken up, retains less of the assimilable and reparative matters, and these are more easily taken up by the absorbing surface; as a necessary consequence, the intestinal tube, although longer than in Solipeds, is far from offering the same capacity.

Analogous considerations explain the reason for the intermediate conformation of the digestive canal in Omnivorous animals.

There is, then, an admirable correlation between the conformation of the digestive tube and the nature of the substances which form the basis of the alimentation of animals; and this harmony is equally apparent when the stomach and intestines are compared with the other apparatus of the economy, and with the natural habits and instincts of creatures. So it is that an animal furnished with an ample stomach and narrow intestine, will have sharp teeth and claws to tear its prey, strength and agility to capture it, and will also possess sanguinary instincts; while another, with its gastric surface greatly diminished, will have intestines as developed in their length as in their capacity, and be distinguished by its peaceful habits, the absence of aggressive claws, and its dental apparatus arranged for crushing and grinding its food—and so on.

Organs annexed to the Abdominal Portion of the Digestive Tube.

These organs are three in number: two glands—the *liver* and *pancreas*, which pour into the small intestine two particular fluids, the *bile* and *pancreatic juice*; and a glandiform organ, the *spleen*, remarkable for its numerous vascular connections with different organs of the digestive apparatus, and which for this reason deserves to be studied with it, although it is doubtful, if not improbable, that it has anything to do with digestion.

Preparation.—These three organs can readily be studied after removing the intestinal mass, as indicated at page 471. In order to examine the details of their organization with more facility, it would be well to detach them altogether, with the diaphragm and kidneys, and to lay out the whole on a table. (To study the relations of these three organs with those of the abdominal cavity, it is advisable to place the subject on its sternum, after removing the intestines, and to detach the posterior part of the body at the loins.)

1. THE LIVER (Figs. 293 to 298)

Situation—Direction.—This organ is situated in the abdominal cavity, to the right of the diaphragmatic region, and in an oblique direction downwards and to the left.

Weight.—The weight of the healthy liver in a middle-sized horse, is eleven pounds.

Form and External Surface.—Removed from its connections with the neighbouring organs, and viewed externally, it is seen to be flattened before and behind, irregularly elongated in an elliptical manner, thick in its centre, and thin towards its borders, which are indented in such a manner as to divide the organ into three principal lobes. This configuration permits it to be studied in *two faces* and a *circumference*.

The *anterior face* is convex, perfectly smooth, and channelled by a wide and deep fissure for the passage of the posterior vena cava. This fissure extends directly from behind to before, and consequently slightly crosses the general direction of the liver; near the point where the vena cava leaves the gland to pass through the diaphragm, are seen the openings of the principal sublobular veins. The *posterior face* is equally smooth and convex, and has also a fissure (the *portal*), by which the vena portæ and the hepatic artery and nerves enter, and by which the biliary ducts emerge from the liver. This groove is slightly concave towards the left, and follows the direction of the liver in proceeding obliquely downwards, backwards, and to the left.

The circumference may be divided into a *superior* or *left*, and an *inferior* or *right border*, united at both extremities by the ellipsis formed by the liver. The *superior border* presents, in proceeding from right to left: 1. The insertion of the ligament of the right lobe. 2. The origin of the fissure for the vena cava. 3. A notch for the œsophagus. 4. The insertion of the left ligament. The *inferior border* is sharp, and offers two deep notches, which divide the liver into three lobes: a superior or right, an inferior or left, and an intermediate one. The *right lobe* is usually of medium volume, and has above, on its posterior face, an appendix in the shape of a small secondary lobule of a triangular form, the base of which corresponds to the commencement of the portal fissure: this is the *portal lobe*, or *lobus Spigelii.*[1] The *left lobe* is nearly always the largest. The *middle lobe* (*lobus quadratus*), the smallest of the three, is itself divided by secondary notches into several digitations or lobules.

Relations.—Viewing the organ in position, in order to study its general relations, it is found that the anterior face is applied against the diaphragm—a disposition which increases its convexity, while diminishing that of its posterior face; and that the latter is in contiguity with the stomach, the duodenum, and the diaphragmatic flexure of the colon.

The connections proper to each lobe are observed to be as follows: 1. The middle lobe corresponds to the centre of the aponeurotic portion of the diaphragm. 2. The left lobe touches the left and inferior part of this aponeurosis, and is prolonged to the corresponding point of the fleshy peripheral band of that muscle. 3. The right lobe is in contact with the right and superior part of the muscle; its upper border touches the right kidney; the pancreas rests against its base, on the posterior face.

Mode of attachment.—The liver is suspended to the sublumbar wall of the abdomen, by the large blood-vessels which enter its fissures; and it is also fixed to the posterior face of the diaphragm by four particular bands. One of these is carried from the anterior face of the liver to the phrenic or tendinous centre, and appears intended to prevent total displacement of the organ; the other three belong to each particular lobe.

A. The *ligament of the anterior face of the liver* (or *coronary ligament*) comprises two series of very short aponeurotic fibres, which, arising from the two borders of the vena cava fissure, go to be fixed to the posterior face of the phrenic centre. The peritoneum is folded over it on each side, in passing from the diaphragm to the liver. The adherence of these fibres to the walls of the vena cava is extremely

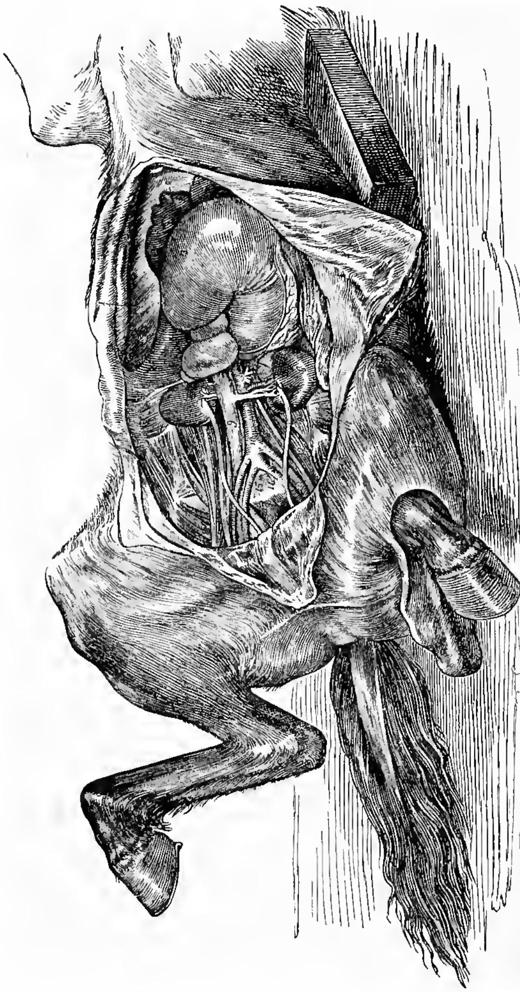
([1] This, according to Flower, should be the *caudate*, not the *Spigelian* lobe; for he appears to have proved that the free, ear-shaped lobe situated to the right of the vena portæ in the Horse, Rhinoceros, and Tapir, is not the *lobus Spigelii*, but the *caudate* lobe—the former being represented by a long, attached, transverse ridge of hepatic tissue situated farther to the left.)

close; and the vena cava itself being thus in a manner united to the tissue of the liver, it happens that the union of the anterior face of the viscus with the phrenic centre could not be more solidly established.

B. The *ligament of the left lobe* is a wide peritoneal fold, between the two layers of which are some fasciculi of white fibrous tissue. It is detached from the aponeurotic centre, to the left of the œsophageal orifice, and is inserted into the left part of the superior border of the liver.

C. The *ligament of the right lobe* is a fold analogous to the preceding, but

Fig. 293.



THE ABDOMINAL CAVITY, WITH THE LIVER AND OTHER ORGANS.
1, Right lobe of the liver; 2, middle lobe; 3, right extremity, or ventriculus of stomach; 4, left extremity of ditto; 5, left abdominal wall.

much shorter, and the origin of which, placed very high and near to the sublumbar parietes, is partly covered by the right kidney. It is inserted into the superior border of the viscus, and sends a small layer to the lobus Spigelii; most frequently, however, this lobule is sustained by a special peritoneal frænum, given off from the anterior border of the kidney.

D. The *ligament of the middle lobe* (the *longitudinal*, *broad*, *falciform*, or *suspensory ligament*) is a falciform and vertical serous layer, the adherent border of which is attached, almost in the median plane, to the posterior face of the diaphragm, and even to the inferior abdominal parietes. At its free border is a fibrous cord (the *round ligament*), the remains of the fœtal umbilical vein. Its upper part enters a secondary notch in the middle lobe, and is prolonged on the anterior face of this to the point where the vena cava enters the diaphragm.

STRUCTURE.—As elements in its structure, the liver offers for study: 1. A *serous membrane.* 2. A *fibrous capsule.* 3. The *proper and fundamental tissue* of the organ.

1. **Serous Membrane.**—This membrane is only an expansion of the peritoneal bands or ligaments already described, and of which the two, on arriving at the organ, separate to become developed on its surfaces, and to completely cover it except in the anterior and posterior fissures.

2. **Fibrous (or Glisson's) Capsule.**—This, the proper envelope of the liver, is formed by a very fine fibrous membrane, closely adherent to the preceding layer on the one side, and to the tissue of the liver on the other. It penetrates the substance of that tissue in passing around the vessels lodged in the posterior fissure, and from its inner face it sends a multitude of lamellar partitions, which separate the hepatic lobules, and form a veritable framework in the interior of the organ. The presence of this capsule has been denied, but its existence is not to be doubted in all the domesticated animals; it is particularly well developed in Ruminants and the Pig.

3. **Proper Tissue of the Liver.**—The proper substance of the liver is distinguished by its bluish-brown or violet hue, the shades of which vary much according to the subjects. It is heavy and compact, and so friable that it is crushed by the most moderate pressure. It is composed of polyhedric masses from $\frac{1}{20}$ to $\frac{1}{10}$ of an inch in diameter, which are readily enough distinguished from one another through the peritoneum on the surface of the organ, particularly when the septa thrown in between them from Glisson's capsule are hypertrophied, from some slight chronic irritation.

Sometimes the *hepatic lobule* is uniform in colour throughout; often it shows a red central point, with a yellow circle around it, and an interrupted red ring circumscribing this again, and which communicates with a similar circle belonging to the adjoining lobules, so as to compose a network on the surface of the gland; at other times the lobules are yellow in the centre and red at the circumference. All these appearances, the study of which at one time was considered of much importance, are uncertain, and may vary in a thousand ways, in combining with one another; so that they really demand but little attention, due as they are to the greater or less degree of plenitude of the different vessels entering the lobule.

As the liver is composed of lobules placed beside each other, we will describe one; as, when its structure is well known, the organization of the entire organ will be understood.

In a *hepatic lobule* we find: 1. *Hepatic* (or *biliary*) *cells.* 2. *Biliary canaliculi* (or *ducts*). 3. *Afferent vessels.* 4. An *efferent vessel.* 5. *Lymphatics.* 6. *Connective tissue.*

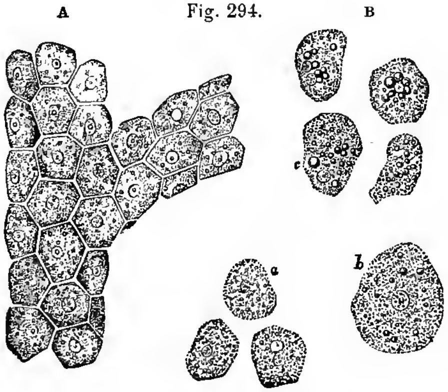
Hepatic cells.—These are polygonal or round, and much resemble squamous epithelium; their diameter varies from $\frac{1}{500}$ to $\frac{1}{200}$ of an inch. They have no enveloping membrane, but contain one or two nuclei with nucleoli, granules coloured by biliary matter, small masses of a substance which has been studied by Bernard and Schiff, and named "animal amidon, or glycogen;" and, lastly, adipose granules, the volume and quantity of which vary with the condition of the animals, or the period of digestion at which the liver is examined. The hepatic cells are situated in the network formed by the vessels of the lobule, and constitute its principal portion.

Hepatic Ducts.—Destined to carry away the bile secreted in the interior of the hepatic lobule, the biliary ducts form around it a kind of girdle that accompanies the interlobular branches of the vena portæ. Within and without, this girdle sends off small prolongations; the first bring it into communication with the ducts of the neighbouring lobules; the second pass to the centre of the lobule, or they surround each cell.

The wall of the biliary ducts is a thin amorphous membrane, lined, near the periphery of the lobule, by polygonal cells, smaller than the hepatic cells, and, beyond, by a kind of endothelium or cuticle.

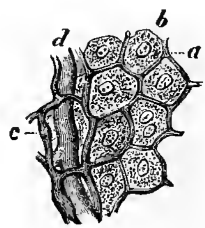
Afferent vessels.—These are the branches of the portal vein and hepatic artery. The portal vein, after reaching the interior of the liver, divides into gradually decreasing vessels, until it terminates in forming the *interlobular veins.* These

Fig. 294.



A, portion of a hepatic column, showing its component secreting cells. B, Secreting cells detached: *a*, In their normal state; *b*, a cell more highly magnified, showing the nucleus and distinct oil-particles; *c*, in various stages of fatty degeneration.

Fig. 295.



BILIARY CAPILLARIES OF THE RABBIT'S LIVER. PART OF A LOBULE, SHOWING THE ARRANGEMENT OF THE BILIARY DUCTS IN RELATION TO THE HEPATIC CELLS.

a, Capillaries of the biliary ducts; *b*, hepatic cells; *c*, biliary ducts; *d*, capillary blood-vessels.

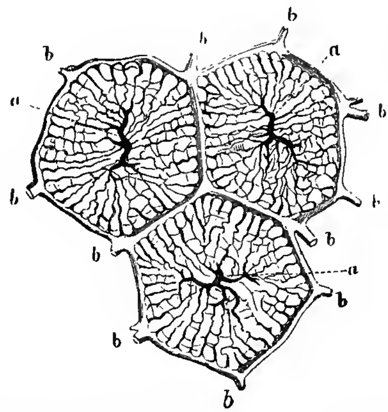
vessels surround the lobule, communicate with the neighbouring interlobular veins, and give off a large number of twigs to the interior of the lobule, where they anastomose, and constitute the hepatic capillary plexus. The hepatic artery furnishes ramuscules, which mix with the ramifications of the portal vein in the (vaginal) plexus. The principal branches of the latter are all directed from the periphery towards the centre of the lobule, where they unite to form the afferent vessel. It results from this arrangement that the hepatic cells which fill the spaces between the vessels, are placed in radiating series.

Efferent vessel.—Situated in the centre of the lobules, this vessel receives all the ramifications of the capillary plexus, and is named the *intra-lobular* or *central sublobular vein.* It is voluminous, and communicates with the other intra-lobular veins. (These intra-lobular veins terminate in the larger trunks that run along the bases of the lobules, and are named the *sublobular veins.*)

Lymphatics.—In a hepatic lobule are found very fine lymphatic vessels that surround the branches of the hepatic plexus, where they form the lymphatic vaginæ, or canals which contain the blood-vessels.

Connective tissue.—The intra-lobular connective tissue is scanty, the lobule being almost entirely composed of cells or capillaries; some trabeculæ, nevertheless, exist around the lymphatic sheaths. There is, however, a larger quantity in the interlobular spaces; and in some animals—especially the Pig—Glisson's capsule sends somewhat thick lamellæ of connective tissue between these lobules.[1]

Fig. 296.



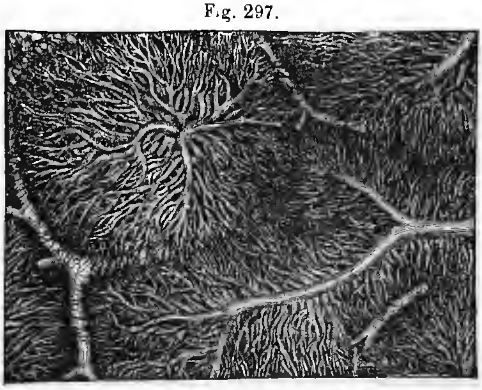
HORIZONTAL SECTION OF THREE SUPERFICIAL LOBULES, SHOWING THE TWO PRINCIPAL SYSTEMS OF BLOOD-VESSELS.

a, a, Intra-lobular veins, terminating in the hepatic veins; *b, b,* interlobular plexus, formed by branches of the portal vein.

Excretory Apparatus (Fig. 298).—This is very simple in Solipeds, and is composed of a vessel named the *ductus choledochus*, resulting from the union of several trunks lodged in the posterior fissure of the liver, and which come from the three lobes. Traced in the substance of the hepatic tissue, these branches divide into more and more attenuated vessels that arise from the periphery of the lobules, and are continuous with the biliary ducts which envelop and penetrate these.

Course.—At its exit from the liver, the ductus choledochus lies between the layers of the gastro-hepatic omentum, and ascends to the wall of the duodenum, which it passes through at about six inches from the pylorus, along with the principal pancreatic duct. The orifices of these two canals are surrounded by a circular mucous fold (*ampulla of Vater*), which is usually very prominent, and acts as a valve in preventing the entrance of alimentary substances into the apertures it encircles; this office it fills so well, that it will not even allow the air with which the duodenum may be inflated, to pass into the ducts.

Fig. 297.



SECTION OF A SMALL PORTION OF THE LIVER OF A RABBIT, WITH THE HEPATIC OR INTRA-LOBULAR VEINS INJECTED

There enter into the structure of the ductus choledochus: 1. A *fibrous membrane*, which some anatomists believe contains unstriped muscular fibres. 2. *Spheroidal epithelium.* 3. Numerous

[1] The description of the hepatic lobule has been intentionally simplified to the utmost, to treatises on histology being left the task of discussing the microscopical details which sometimes cause a lobule to be considered as a collection of tubes placed at the end of the branches of the biliary ducts, at other times as a portion of a conglomerate gland full of blood-vessels.

racemose glands, opening on the surface of the epithelium by very small orifices.

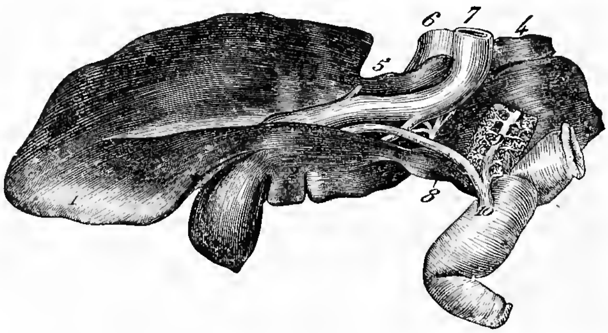
VESSELS AND NERVES OF THE LIVER.—The *blood-vessels* are the hepatic artery, portal vein, and sublobular veins.

The *hepatic artery* is a branch of the cœliac, and enters the gland by the posterior fissure, in company with the portal vein and ductus choledochus. In the liver it divides into very fine ramifications, which join the intra-lobular plexus, anastomose on the surface of the biliary ducts, or are expended either on the serous membrane, or in the walls of the portal vein.

The *portal vein* is the functional vessel of the liver. It reaches that organ by the posterior fissure, and Glisson's capsule accompanies its ramifications as far as the hepatic lobules, where they form the plexus of subhepatic veins.

The *supra-hepatic* (*sublobular*) *veins* are so named because they gain the antero-superior face of the viscus, to open into the posterior vena cava. They carry away the blood that has been brought by the portal vein and hepatic artery. Their origin is due to the union of the intra-lobular veins, which make a passage

Fig. 298.



EXCRETORY APPARATUS OF THE HORSE'S LIVER.

1, left lobe of the liver; 2, middle lobe; 3, right lobe; 4, lobus Spigelii (caudate lobe); 6, posterior vena cava at its entrance into the liver; 7, vena portæ; 8, ductus choledochus; 9, pancreatic duct; 10, common entrance of these two ducts into the small intestine.

through the hepatic tissue with which their walls are immediately in contact, gradually join each other, and enter the posterior vena cava on its way through the anterior fissure of the liver. The number of trunks (*hepatic*) entering this vessel is considerable, but the majority are very small; the principal confluent is placed at the anterior extremity of the fissure.

The *lymphatics* form a fine superficial plexus, easy to inject; with deeper networks placed around the vessels that penetrate by the posterior fissure. In the lobules they are disposed as described above. Joined to the lymphatics of the stomach, they constitute a single trunk that goes to the sublumbar receptacle.

The *nerves* are more particularly derived from the solar plexus, although the pneumogastric and diaphragmatic also supply filaments to the liver. They interlace around the hepatic artery and portal vein; their mode of termination is unknown.

Functions.—The most important considerations are attached to the study of the functions of the liver; but we cannot enter into them in detail without going beyond our subject.

The liver more especially elaborates bile and sugar. It secretes the bile at the expense of the blood of the portal vein, which comes from the intestinal tunics charged with assimilable substances absorbed by the veins of the villi.

The bile is, therefore, in this respect an excrementitious secretion; though all its elements are not excreted, some of them acting on the alimentary substances, and others being absorbed. From the most recent researches, it would appear that it has a share in the purification of the blood, in digestion, and in calorification—in the latter especially, as its absorbed elements are very rich in carbon and hydrogen, bodies eminently fitted for the production of animal heat.

The liver is also a glycogenetic gland, this function having been demonstrated to pertain to it by Bernard. The sugar formed in the liver finds its way into the blood, and leaves the organ by the sublobular veins. It is elaborated in the hepatic cells, by the transformation of the substance known as "animal amidon," which is brought into contact with a kind of diastaste that exists with it in their interior.

It will thus be seen that the liver furnishes two very different products—bile and sugar. The knowledge of this fact, combined with the internal arrangement of the organ, has led some anatomists to consider the organ as two glands reciprocally contained within each other. According to them, one gland is tubular, and formed by the system of biliary ducts—this gland secretes the bile: the other gland is constituted by the hepatic cells, which produce the sugar. But this hypothesis should be rejected, for it is probable that the sugar and bile are produced in the large hepatic cells, and that the first passes into the veins, while the second is poured into the biliary ducts.

In Solipeds, the secretion of bile, though most active during the digestive period, yet goes on in a continuous manner.

(Certain deductions of a pathological kind are based upon the foregoing anatomical facts, and have an important bearing with regard to comparative pathology. They have been pointed out by Wilson, and are as follows: Each lobule is a perfect gland; its structure and colour are uniform, and it has the same degree of vascularity throughout. It is the seat of a double venous circulation; the vessels of the one—*hepatic*—being situated in the centre of the lobule, and those of the other—*portal*—at the circumference. Now, the colour of the lobule, as of the entire liver, depends chiefly on the proportion of blood contained within these two sets of vessels; and so long as the circulation is natural, the colour will be uniform. But the instant that any cause is developed which will interfere with the free circulation of either, there will be an immediate diversity in the colour of the lobule.

Thus, if there be any impediment to the free circulation of the venous blood through the heart or lungs, the circulation in the hepatic veins will be retarded, and the sublobular—or supra-hepatic—and intra-lobular veins will become congested, giving rise to a more or less extensive redness in the centre of each of the lobules; while the marginal or non-congested portion presents a distinct border of a yellowish white, yellow, or green colour, according to the quantity or quality of the bile it may contain. "This is '*passive congestion*' of the liver, the usual and natural state of the organ after death;" and as it commences with the hepatic vein, it may be called the first stage of hepatic venous congestion.

But if the causes which produced this state of congestion continue, or be from the beginning of a more active kind, the congestion will extend through the lobular venous plexuses "into those branches of the portal vein situated in the *interlobular fissures*, but not to those in the *spaces*, which, being larger, and giving origin to those in the fissures, are the last to be congested." In this second stage the liver has a mottled appearance, the non-congested substance is arranged in isolated, circular, and ramose patches, in the centres of which the spaces and parts of the fissure are seen. This is an extended degree of *hepatic venous congestion*; it is "*active congestion*" of the liver, and very commonly attends disease of the heart and lungs.

These are instances of *partial congestion*; but there is sometimes *general congestion* of the organ. "In general congestion, the whole liver is of a red colour, but the central portions of the lobules are usually of a deeper hue than the marginal portions.")

Development.—The liver of the fœtus is remarkable for its enormous development. Its function commences early, for at birth the intestines are filled with *meconium*—a product of the biliary secretion. A more detailed description will be given when the general development of the fœtus comes to be studied.

2. The Pancreas.

This organ has the greatest resemblance to the salivary glands in its structure and physical properties; and for this reason it has been named the *abdominal salivary gland*.

Situation—Weight.—It is situated in the sublumbar region, across the aorta and posterior vena cave, in front of the kidneys, and behind the liver and stomach. Its weight is seventeen ounces.

Form and Relations.—The pancreas is rather irregular and variable in form, according to the kind of animal. Flattened above and below, traversed obliquely from its inferior to its superior face by an opening for the passage of the portal vein, and which is named the *pancreatic ring*, this gland is sometimes triangular, sometimes oblong, and curved on itself; it is under the latter form that we will notice it.

Its *faces* present the lobulated aspect of salivary glands. The *superior* adheres by connective tissue to the aorta, posterior vena cava, cœliac trunk, solar plexus, splenic vessels, and the right kidney and supra-renal capsule; it is covered by the peritoneum for a certain portion of its extent. The *inferior* is related to the base of the cæcum and the fourth portion of the colon, through the medium of a thick layer of connective tissue. The *anterior border*, concave and undulating, is in contact with the duodenum and the left extremity of the stomach. The *posterior* is very convex, especially to the right, and near its middle it presents a notch for the reception of the portal vein before its entrance into the ring. The *right extremity* (or *head*)—the thinnest—adheres to the duodenum, and shows the excretory ducts of the gland. The *left* is carried towards the base of the spleen, in passing between the left extremity of the stomach and the kidney of the same side.

Structure.—Superficially, it resembles the salivary glands, but in reality it is not a racemose gland. It is an acinous gland in which the elongated *culs-de-sac*, filled with polyhedral cells, have their axis occupied by a vessel and a cord of connective tissue. The excretory vessels disappear on reaching these *culs-de-sac*, so that the secreted products are infiltrated between the cells to reach the duct of Wirsung.

The gland receives its blood by the hepatic and great mesenteric arteries; the nerves come from the solar plexus.

Excretory apparatus.—The pancreas has two excretory ducts—a principal, described by Wirsung, whose name it bears, and an accessory. The *duct of Wirsung*, lodged in the substance of the gland, but nearer the superior than the inferior face, at first comprises two or three thick branches, which soon unite to form a single trunk that emerges from the pancreas by the left extremity of the organ. Larger than the ductus choledochus, it opens, as already stated, at the same part of the duodenal surface. The *accessory* or *azygos duct* (*ductus pancreaticus minor*) is much smaller; it leaves the principal trunk, receives some branches in its passage, and opens alone into the small intestine, directly opposite the duct of Wirsung.

The ductus choledochus and the duct of Wirsung do not pass directly through the wall of the intestine, but obliquely, like the entrance of the ureters into the bladder. They open in the middle of a circular valve—the *ampulla of Vater*. This ampulla is limited by a thick primary mucous fold, and within this is a second—thinner—beneath which the ductus choledochus opens; at the bottom of the space circumscribed by this second fold, beneath a free mucous lip, is seen the duct of Wirsung. Such is the arrangement of the ampulla of Vater in the Horse.

Functions.—From the researches of Bernard, it appears established that the fluid secreted by the pancreas emulsifies fatty matters, and renders them absorbable.

3. The Spleen (Fig. 299).

The spleen differs from glands, not only in the absence of an excretory duct, but also in the other details of its organization. It has been considered as a vascular gland, the uses of which are not yet determined in a precise manner.

Situation.—It is situated in the diaphragmatic region, close to the left hypochondriac, and appears as if suspended in the sublumbar region, as well as at the great curvature of the stomach.

Form—Direction—Relations.—The spleen is falciform, and directed obliquely downwards and backwards. It has *two faces*, *two borders*, and a *point*.

The *external face* is in relation with the muscular portion of the diaphragm, and is moulded to it. The *internal*, slightly concave, touches the large colon; it has sometimes a small lobule, or offers traces of lobulation. The *posterior border* is convex, thin, and sharp. The *anterior*, thicker, concave, and bevelled at the expense of the internal face, is channeled by a slight longitudinal fissure (or *hilus*) that lodges the splenic vessels and nerves; it receives the insertion of the great mesentery, by which it is attached to the greater curvature of the stomach. The *base*, or *superior extremity*, is thick and wide, and is related to the left kidney and the corresponding extremity of the pancreas; it shows the insertion of the suspensory ligament. The *point*, or *inferior extremity*, is smooth and thin.

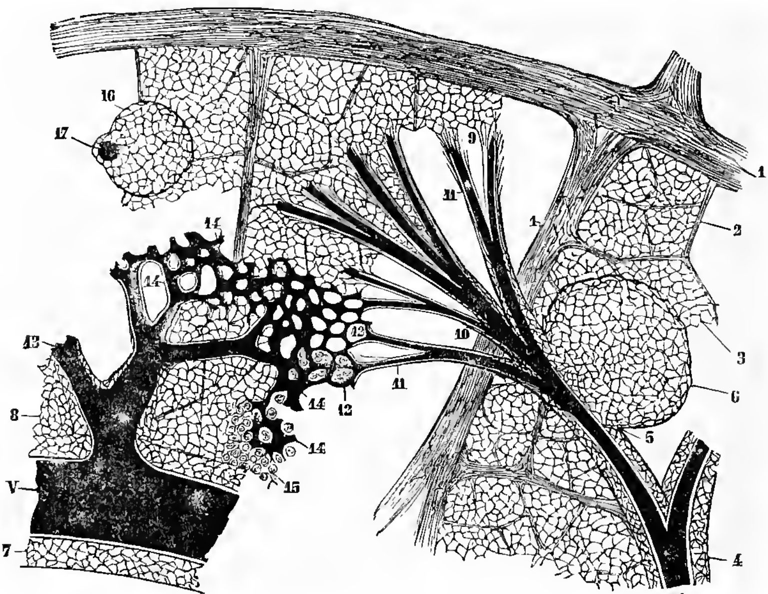
Weight.—The average weight is 32 ounces; but it is sometimes of enormous dimensions—as much as three or four times its normal volume.

Mode of attachment.—The spleen is a floating organ, the displacements of which are limited by a *suspensory ligament*, and the *great* (or *gastro-splenic*) *omentum*. The first is a peritoneal fold which proceeds from the anterior border of the left kidney and the sublumbar wall, and is strengthened by the elastic fibrous tissue comprised between its two layers. It is fixed to the base of the spleen, and is confounded, inwardly, with the great omentum. The latter is already known as proceeding to the colon, and in its passage becoming attached to the splenic fissure, whence it extends over the surface of the organ to form its serous covering.

STRUCTURE.—The tissue of the spleen has a violet-blue colour, sometimes approaching to a red hue; it is elastic, tenacious, and soft, yields to the pressure of the finger, and retains its imprint. Enveloped externally by the *peritoneum*, its substance includes a *fibrous framework*, *splenic pulp*, *Malpighian corpuscles*, *vessels*, and *nerves*.

Serous membrane.—This is spread over the whole surface of the organ, except in the fissure of the anterior border. Its internal face adheres most intimately

Fig. 299.



STRUCTURE OF THE SPLEEN (DIAGRAMMATIC).

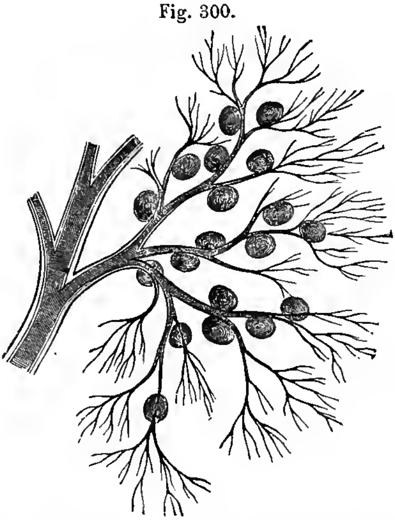
A, Artery; V, vein. 1, Splenic trabeculæ; 2, finer trabeculæ; 3, reticulum of the splenic pulp; 4, lymphoid infiltration into the sheath of the arteries; 5, its continuation with a Malpighian corpuscle; 6, membrana propria; 7, sheath of the vein; 8, recticulum of the splenic pulp; 9, termination of the fibrillar sheath of the capillaries; 10, tuft of arteries; 11, arterial capillaries; 12, their opening into the intermediate tracts of the pulp; 13, veins; 14, venous capillaries; 15, part of the pulp containing the remains of cells; 16, Malpighian corpuscle attached to (17) an artery, seen in a section perpendicular to the axis of the vessel.

to the proper tunic of the spleen. It is only an expansion of the serous bands which limit the movements of the viscus.

Fibrous framework.—Under the peritoneal membrane is a thick, resisting, fibrous tunic, roughened and granular on its exterior, and sending from its deep face into the interior of the mass a multitude of prolongations called *trabeculæ*, which cross in all directions, forming a cellular network, in the numerous narrow meshes of which are the other elements of the organ. In washing out a morsel of spleen in a jet of water, the latter are removed, and the outlines of this fibrous structure are fully exposed. If a stream of water be passed through the splenic artery, the same result will be arrived at. Kölliker has found in the proper tunic of the spleen, and in its trabeculæ, a particular contractile tissue—the *muscular cell-fibres*—mixed with fasciculi of elastic or inelastic fibrous tissue. (The proper coat, the sheaths of the vessels, and the trabeculæ, consist of a dense mesh of white and yellow elastic fibrous tissues, the latter considerably predominating. It is owing to the presence of this tissue that the spleen possesses a considerable amount of elasticity, admirably adapted for the very great variations in size that it presents in certain circumstances. In some of the Mammalia, in addition to the usual constituents of this tunic, are found numerous pale, flattened, spindle-shaped nucleated fibres, like unstriped muscular fibre. It is probably owing to this structure that the spleen possesses, when acted upon by the galvanic current, faint traces of contractility.)

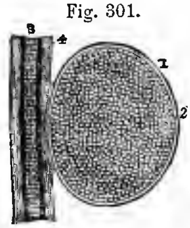
Splenic pulp.—This name is given to a reddish pultaceous material, which partly occupies the alveolar network formed by the intersections of the trabeculæ. It is sustained by a very delicate reticulum of connective tissue, and is composed

Fig. 300.



BRANCH OF SPLENIC ARTERY WITH ITS RAMIFICATIONS STUDDED WITH MALPIGHIAN CORPUSCLES.

Fig. 301.



A SINGLE SPLENIC CORPUSCLE, FROM THE SPLEEN OF THE OX.

1, External tunic, or membrana propria; 2, granular contents; 3, part of a small artery; 4, its sheath, derived from the external tunic of the spleen, with which the corpuscle is closely connected.

of numerous elements, such as pigment granules, free nuclei, large cells with several nuclei, lymphoid elements, and blood-globules in a state of decomposition or transformation. These globules are free or enveloped in an albuminoid membrane.

Malpighian corpuscles.—These are contained, like the splenic pulp, in the meshes of the fibrous framework of the spleen, and are covered by that pulp. Distributed on the course of the small arteries, these corpuscles, which are visible to the naked eye, are little closed sacs of a whitish colour. They are composed of an adventitious tissue of arteries, in which are accumulated, at certain points, lymphoid elements. They are, therefore, analogous to closed follicles in their structure. (The proper substance of the spleen consists of coloured and colourless elements. The coloured are composed of red blood-corpuscles and coloured corpuscles, either free or included in cells. Sometimes unchanged blood-discs are seen included in a cell ; but more frequently the included blood-discs are altered both in form and colour. Besides these, numerous deep-red, or reddish-yellow, or black corpuscles and crystals, either single or aggregated in masses, are seen diffused throughout the pulp substance; these, in chemical composition, are closely allied to the hæmatine of the blood. The colourless elements consist of granular matter; nuclei, about the size of the red blood-discs, homogeneous or granular in structure ; and nucleated vesicles in small numbers. These elements form a large proportion of the entire bulk of the spleen in well-nourished animals ; whilst they diminish in number, and occasionally are not found at all, in starved animals. The application of chemical tests shows that they are essentially a proteine compound. The splenic or Malpighian corpuscles are round, whitish, semi-opaque bodies, glutinous in consistence, and disseminated throughout the substance of the organ. They are more distinct in early than in adult life or old age, and vary considerably in size and number. From the manner in which they are appended to the sheaths of the smaller arteries and their branches, they resemble the buds of the moss-rose. Each consists of a membranous capsule, composed of fine pale fibres interlacing in all directions. The blood-vessels ramifying on the surface of the corpuscles, are the larger ramifications of the arteries to which the sacculus is connected, and also of a delicate capillary plexus, similar to that surrounding the vesicles of other glands. These vesicles have also a close relation with the veins, and the vessels begin on the surface of each vesicle throughout the whole of its circumference, forming a dense venous mesh in which each of these bodies is enclosed. It is probable that, from the blood contained in the capillary network, the material is separated which is occasionally stored up in their cavity ; the veins being so placed as to carry off, under certain conditions, those contents that are again to be discharged into the circulation. Each capsule contains a soft, white, semi-fluid substance, consisting of granular matter, nuclei similar to those found in the pulp, and a few nucleated cells, the composition of which is apparently albuminous. These bodies are very large, after the early periods of digestion, in well-fed animals, and especially those fed upon albuminous diet. In starved animals, they disappear altogether.)

Arteries.—These emanate from the splenic artery at different elevations, and plunge into the tissue of the spleen, preserving their reciprocal independence. Their terminal ramifications do not open, as has been said, into venous sinuses, but into minute tufts of capillaries, which traverse the splenic pulp, to be continued by the venous network.

Veins.—All the venous branches of the spleen open into the splenic vein, and are lodged, with the corresponding artery, in the fissure of the organ. Traced from their commencement, they are seen to gradually lose their constituent membranes, and to open into sinuses which are only lined by the endothelium of the vessels. It is in these sinuses that the network of venous capillaries which succeed the arterial capillaries, originates.

Lymphatic vessels.—These are found on the external surface of the organ, and along the track of the blood-vessels. (There appear to be two systems of lymphatics in the spleen of the Horse—one belonging to the trabeculæ, which is in continuity with the lymphatics of the capsule ; and another accompanying the branches of the splenic artery and its branches, investing these vessels like a sheath. These two systems may be named, respectively, the trabecular and the perivascular lymphatics. Occasionally, the latter can be injected from the former. The perivascular lymphatics appear to arise in a delicate adenoid tissue enclosing the smaller arteries, partly from a plexus, and partly from lymph-cavities, the walls of which are formed by endothelial cells alone. The trabecular system arises in a plexus lying between the muscle-cell fasciculi.

There is, according to Kyber, a distinct difference between the splenic pulp and the adenoid tissue surrounding the artery, both histologically and pathologically. The latter he regards as performing the usual functions of the lymphatic system ; while the former, he conceives, may exercise that digestive action on the albuminoids of the spleen, which Schiff has demonstrated takes place.)

Nerves.—They are derived from the solar plexus, and, enveloping the splenic artery, with it enter the spleen. (They appear to be very large, but this appearance is due to the great proportion of ordinary fibrous tissue investing them.)

From what has been said above respecting the arrangement of the splenic arteries and veins, it will be perceived that the areolæ formed by the trabeculæ of the fibrous framework contain the pulp, and are not in direct communication with the arterial capillaries. Such an organization belongs to erectile tissues. The arteries communicate with the veins proper by venous canals channeled in the splenic pulp, and are lined only by an endothelium of elliptical cells. These venous canals are extremely dilatable, especially in the Horse. When the splenic vein is inflated, their walls separate and press back the pulp, they become considerably enlarged, and distend the cells of the fibrous structure ; but the air does not reach the interior of these cells.

FUNCTIONS.—Nothing precise is known regarding the functions of the spleen ; though they must be of very secondary importance, because animals in which the organ has been extirpated, and which have recovered from the operation, have continued to live in apparent good health. Numerous hypotheses have been formed on this subject ; two of which, founded on the study of the anatomical peculiarities of the spleen-tissue, and on exact physiological observations, are as follows : 1. *The spleen is a diverticulum for the portal vein.* 2. *The red corpuscles of the blood are destroyed in the spleen.*

With regard to the first hypothesis, it is evident that, owing to the presence of the venous sinuses already mentioned, and their great dilatability, as well as to the elasticity and contractility of the spleen-tissue, the organ is favourably constructed to act as a blood-reservoir. Goubaux, on the other hand, has demonstrated that there is always an augmentation in the spleen's volume when an animal has ingested large quantities of water, the consecutive absorption of which determines a certain tension in the portal venous system.

The second opinion, emitted by Kölliker, is founded on the existence in the splenic pulp of blood-corpuscles in a state of decomposition, and in the analyses made by J. Beclard of the blood in the splenic vein, which have proved that there is a notable diminution in the proportion of these. These analyses have, however, been much questioned, and, recently, Malassez and Picard have shown results which are in favour of the third hypothesis. They have found that the red corpuscles increase in the blood of the splenic vein, while the proportion of iron diminishes in the pulp ; and from this fact they conclude that in the spleen there is a new formation of corpuscles, in which the iron contained in the splenic pulp participates.

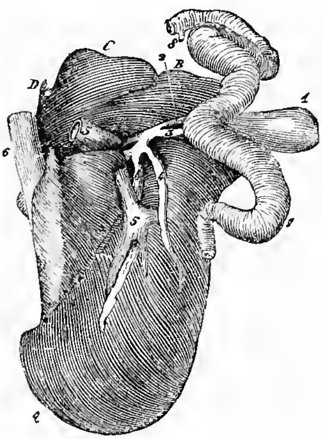
It is to be remarked that, in the researches undertaken to discover the functions of the spleen, account has not been taken of the connections existing between this organ and the great omentum in the majority of Mammals, and which testify that the spleen is only, properly speaking, a vascular appendage placed on the course of this omentum. But the uses of this vast peritoneal fold are themselves little understood. Might they not be included with those which are presumed to belong to its appended organ ?

Differential Characters in the Organs Annexed to the Abdominal Portion of the Digestive Canal in the other Animals.

The important differences these organs offer in the domesticated Mammals are more particularly observed in the liver.

1. *Liver.*—In the domesticated Mammals other than Solipeds, the liver exhibits variations in form, volume, and position, which have no influence on its organization: so that the study of these possesses only a moderate amount of interest. This is not so, however, with regard to the excretory apparatus, the arrangement of which is complicated, and becomes very interesting. The biliary duct, in fact, on leaving the fissure of the portal vein, and before reaching the intestine, gives rise to a particular conduit which is detached at an acute angle, and which, after a course of variable length, according to the size of the animal, becomes dilated into a vast sac, the so-called *gall-bladder* (Figs. 302, 303).

Fig. 302.



LIVER OF THE OX.

A, Inferior extremity of the liver; B, superior extremity; C, Spigelian (caudate) lobe. 1, Gall-bladder; 2, cystic duct; 3, ductus choledochus; 4, root of that duct; 5, posterior vena cava; 7, intestine; 8, insertion of the pancreatic duct.

In all treatises on anatomy, the special conduit is designated the *cystic* (or *bile*) *duct*, that portion which precedes its origin being named the *hepatic duct;* while the appellation of *ductus communis choledochus* is reserved for the section which goes to the intestine. But these distinctions are vicious, and we limit ourselves to the recognition of: (*a*) A ductus choledochus exactly like that of Solipeds, and like it extending from the posterior fissure, where it originates by the union of several branches, to the duodenum; and (*b*) a *cystic duct*, which branches suddenly into the choledic duct, and terminates in the *gall-bladder*.

a. The *gall-bladder* (Fig. 302, 1) is a reservoir with membranous walls, in which the bile accumulates during the intervals of digestion. This sac, lodged wholly, or in part, in a fossa on the posterior face of the liver, is oval or pyriform, and presents a *fundus* and *neck*. Its parietes comprise three *tunics:* an *external*, of peritoneum; a *middle*, formed of fibrous tissue; and an *internal*, or mucous, continuous with that of the various biliary ducts.

b. The *cystic duct* (Fig. 302, 2) extends in a straight line from the neck of the gall-bladder to the choledic duct. It adheres intimately to the tissue of the liver, and does not exhibit, internally, the spiral valves which have been described in Man. In opening it longitudinally, there are discovered, at least in Ruminants and the Carnivora, very small orifices which pierce the wall adherent to the tissue of the liver: these are the openings of several minute, but special, biliary canals, named the *hepatico-cystic ducts.*

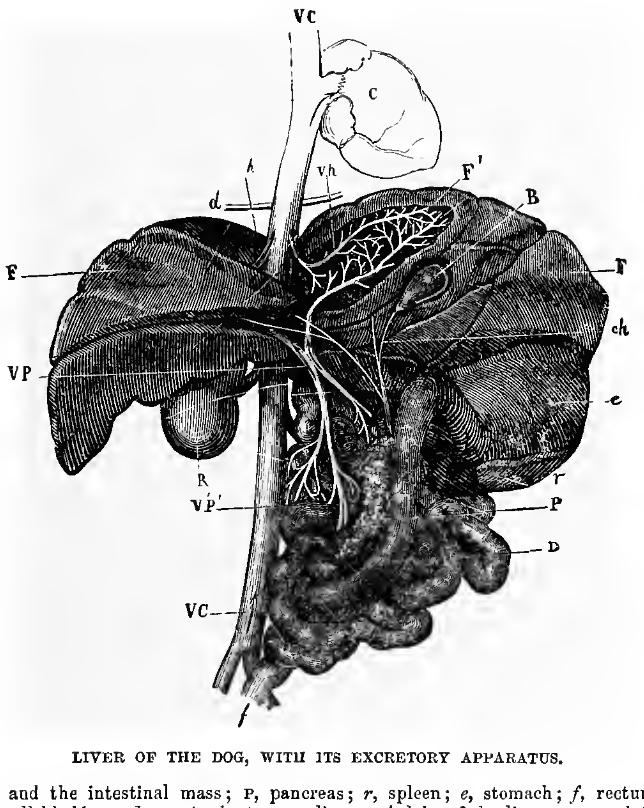
c. The *ductus communis choledochus* (Fig. 302, 3) comports itself exactly as in Solipeds. It is much wider than the cystic duct, and opens sometimes alone, sometimes with the pancreatic canal, into the duodenum in a manner which, up to a certain point, reminds one of the mode of termination of the ureters. Instead of passing perpendicularly across the intestinal parietes, it first pierces the muscular layer, follows for a short distance between it and the mucous membrane, and then opens on the internal face of the latter by an orifice which is encircled by a valvular fold, as in the Horse.

Such is the excretory apparatus belonging to the liver in animals provided with a gall-bladder. In these animals the biliary secretion is certainly continuous, as in the Horse; but in the intervals of digestion, the bile, instead of flowing directly on to the intestinal surface, passes into the gall-bladder by the cystic duct, and there accumulates. When digestion commences again, this reserve of bile is thrown into the ductus choledochus by the contraction of the muscular fibres of the cyst, and by the pressure of the abdominal viscera; it meets that which comes directly from the liver, and with it is carried to the duodenum.

We will now glance at the particular arrangement of this viscus in each species.

In the **Ox**, the liver is entirely confined to the right diaphragmatic region. It is thick, voluminous, and scarcely notched at its periphery; so that it is difficult, if not impossible, to distinguish three lobes in it. In Fig. 302, this excretory apparatus is represented, the lobus Spigelii alone being detached from the mass of the organ. The gall-bladder, fixed towards

Fig. 303.



LIVER OF THE DOG, WITH ITS EXCRETORY APPARATUS.

D, Duodenum and the intestinal mass; P, pancreas; *r*, spleen; *e*, stomach; *f*, rectum; R, right kidney; B, gall-bladder; *ch*, cystic duct; F F, liver; F′, lobe of the liver, prepared to show the distribution of the vena portæ and hepatic vein; VP, vena portæ; V*h*, hepatic vein; *d*, diaphragm; VC, vena cava; C, heart.

the superior extremity, is nearly always floating; near its neck it receives the insertion of several large conduits, which come directly from the upper part of the liver. The ductus choledochus opens alone at a great distance from the pylorus; Colin has found it to be 24½ inches in one cow, and 29½ inches in another. In the **Sheep** and **Goat**, the form and position of the liver differs but little from that of the Ox. The ductus choledochus, however, unites with that of the pancreas, and terminates at from 12 to 16 inches from the pylorus.

In the **Camel**, the liver has the same arrangement as in the other Ruminants, except that its posterior face is divided, lobulated, and much reticulated.

In the **Pig**, the liver has three well-marked lobes; the middle carries the gall-bladder. The ductus choledochus opens alone at 1 or 1½ inches only from the pylorus.

In the **Dog** and **Cat,** the liver is very voluminous, is deeply notched, and is divided into five principal lobes. The middle lobe has the gall-bladder attached to it, and gives it complete lodgment in a fossa.

In the **Dog,** the ductus choledochus, joined to a small branch from the pancreatic duct, enters the intestine at a variable distance from the pylorus, depending upon the size of the animal, but usually between 1½ and 4⅗ inches. In the portion comprised between the intestine and the origin of the cystic duct, it receives several biliary canals of somewhat considerable diameter. In the **Cat,** the ductus choledochus is most frequently inserted from about 1 to 1½ inches from the pyloric orifice; it opens immediately alongside the pancreatic duct, when it does not join it.

2. *Pancreas.*– In the **Ox,** the pancreas is not placed across the sublumbar parietes, but is comprised between the layers of the mesentery, to the right of the great mesenteric artery. The excretory duct is single, and opens into the small intestine at from 14 to 16 inches beyond the ductus choledochus.

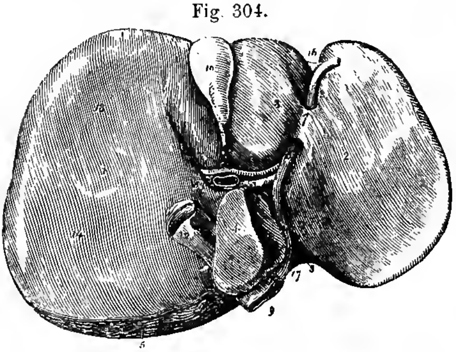
In the **Sheep** and **Goat,** there is the same general arrangement, but the excretory ducts opens with that of the liver.

In the **Pig,** a portion of the pancreas is situated in the sublumbar region, between the large tuberosity of the stomach and the last flexure of the colon; the other portion is lodged in the duodenal frænum. The duct of Wirsung is inserted at from 4 to 6 inches behind the ductus choledochus.

The pancreas of the **Dog** is extremely elongated, and included between the layers of the mesentery which sustain the duodenum. It is curved at its anterior extremity, behind the stomach, to one side of the median line. Its excretory duct—usually single—pierces the intestinal membranes 2 inches beyond the hepatic duct (Fig. 290, *m*). Except in the mode of insertion of the excretory duct, which has been described in noticing the ductus choledochus, the pancreas of the **Cat** comports itself exactly like that of the Dog.

3. *Spleen.*—In **Ruminants,** the spleen is not supported by the great omentum, but adheres to the left side of the rumen and diaphragm. It is not falciform, and its breadth is the same throughout its extent. In the **Carnivora,** it is suspended to the great omentum at a certain distance from the left sac of the stomach. It is irregularly falciform, its point is less acute than in Solipeds, and is directed upwards.

Fig. 304.



UNDER SURFACE OF THE HUMAN LIVER.

1, Right lobe; 2, left lobe; 3, lobus quadratus; 4, lobus Spigelii; 5, lobus caudatus; 6, longitudinal fossa; 7, pons hepatis; 8, fossa of ductus venosus; 9, inferior vena cava; 10, gall-bladder; 11, transverse fossa; 12, vena cava; 13, depression corresponding to the curve of the colon; 14, double depression produced by right kidney and suprarenal capsule.

Comparison between the Annexed Organs of the Abdominal Portion of the Digestive Canal in Man with those of Animals.

1. *Liver.*—Like that of Ruminants, the liver of Man is situated in the right excavation of the lower face of the diaphragm. Its direction is nearly horizontal; its shape is oval, and its average weight from 49 to 53 ounces. The posterior border is thick and round; the anterior border and extremities thin and sharp. The upper face, which in expiration ascends to the fourth rib, is divided into two portions or lobes—right and left, by the falciform ligament; it is smooth and convex. The inferior face has three furrows, or fossæ: two longitudinal, united by a transverse, resembling altogether the letter H. The transverse furrow represents that on the posterior aspect of the liver of animals, and its destination is the same. The right longitudinal furrow lodges the obliterated umbilical vein; the left, well marked before and behind, lodges the gall-bladder in front, and the inferior vena cava behind. This face has four lobes, the right and left, and two middle lobes. In front of the transverse furrow is the lobus quadratus, and behind the same fissure is the lobus Spigelii.

Nothing is to be said of its structure, and the arrangement of its *excretory apparatus* is identical with that of the Ox.

On the lower face of the right lobe are three depressions: an anterior or *impressio colica;* a deep middle one, *impressio vesicæ;* and a small posterior one, which receives the supra-renal capsules, *impressio renalis.*

2. *Pancreas.*—This organ is very elongated transversely, like that of the Dog and Cat. It is closely applied against the lumbar vertebræ, as in the Horse, but its anterior face is much more enveloped by the peritoneum. Its right extremity rests on the duodenum, while the left corresponds to the spleen and left kidney. Its texture is consistent, and of a greyish-white colour. The duct of Wirsung terminates, along with the ductus choledochus, in the ampulla of Vater.

3. *Spleen.*—This is not falciform, but quadrangular; its inferior extremity is larger than the superior. It is attached to the stomach by the great omentum, and its inner face is divided into two portions by a salient ridge; a little in front of this is a fissure—the *hilum lienis*—by which vessels enter it.

CHAPTER III.

The Digestive Apparatus of Birds.

Constructed on the same plan as that of Mammals, the digestive apparatus of *Birds* nevertheless offers in its arrangement several important peculiarities, which will be hurriedly noticed in reviewing, from the mouth to the anus, its different sections.

Mouth.—The essentially distinctive character of the mouth of Birds consists in the absence of *lips* and *teeth*, these organs being replaced by a horny production fixed to each jaw, and forming the salient part termed the *beak.* In the *Gallinacæ*, the beak is short, pointed, thick, and strong, the upper mandible being curved over the lower. In *Palmipeds*, it is longer, weaker, flattened above and below, widened at its free extremity, and furnished within the mouth, on the borders of each mandible, with a series of thin and sharp transverse laminæ to cut the herbage.

The muscular appendage, or *tongue*, lodged in the buccal cavity, is suspended to a remarkably mobile hyoidean apparatus. Covered by a horny epithelium, and provided at its base with several papillæ directed backwards, this organ always affects the form of the lower jaw: in **Poultry** it is like the barbed head of an arrow, the point being directed forwards; in **Pigeons** this saggital form is still more marked: in **Geese** and **Ducks**, on the contrary, and in consequence of the wide shape of the beak, it has not this disposition, and is softer and more flexible than in the Gallinacæ.

With regard to the *salivary glands* annexed to the mouth, they are imperfectly developed, the presence of the fluids they secrete being less necessary in Birds than in Mammals, as the food is nearly always swallowed without undergoing mastication; consequently insalivation is all but useless.

Gurlt[1] speaks of a *parotid gland* situated beneath the zygomatic arch, the duct of which opens into the mouth behind the commissure of the jaws. Meckel names this organ the *angular gland of the mouth*, and says that it is difficult to regard it

[1] Gurlt, *Anatomie der Hausyogel.* Berlin: 1849.

as representing the parotids, any more than the glands of the cheeks and lips. Duvernoy[1] categorically assimilates it with the latter.

The *sublingual glands* lie in the median line throughout nearly their whole extent, and form an apparently single and conical mass, whose apex occupies the re-entering angle formed by the union of the two branches of the lower maxilla.

According to Duvernoy, the submaxillary glands are represented by two very small organs situated behind the preceding. Their existence, however, is far from being general; for among common poultry, the **Turkey** was the only bird in which Duvernoy observed these submaxillary glands.

PHARYNX (Fig. 305, 2).—This cavity is not distinct from the mouth, the soft palate being entirely absent in Birds. On its superior wall may be remarked the guttural orifice of the nasal cavities: a longitudinal slit divided into two by the inferior border of the vomer. Below is another less extensive slit, the entrance to the larynx, and which is remarkable for the complete absence of the epiglottidean operculum.

ŒSOPHAGUS.—This canal is distinguished by its enormous calibre and great expansibility. Its walls are very thin, and contain in their substance lenticular glands, easily seen in an inflated œsophagus, in consequence of the tenuity and transparency of its textures.

At its origin, the œsophageal canal is not separated from the pharynx by any constriction; in its course it lies alongside the long muscle of the neck, and the trachea; its terminal extremity is inserted into the first compartment of the stomach, or succentric ventricle, after entering the thorax and passing above the origin of the bronchi, between their two branches.

In *Palmipeds*, the œsophagus is dilated in its cervical portion in such a manner as to form, when its walls are distended, a long fusiform cavity.

In *Gallinacæ* (Fig. 305, 3, 4, 5), this dilatation does not exist; but the œsophagus presents in its course, and immediately before entering the chest, an ovoid membranous pouch named the *crop* (or *ingluvies*). In the œsophagus of these Birds, then, we find two distinct sections, joined end to end—one superior or cervical, the other inferior or thoracic on the limit of which is the *crop*. The latter does not differ in its structure from the œsophagus, and is a temporary reservoir for the food swallowed by the animal during its meal, and where it is softened by being impregnated with a certain quantity of fluid; after which it is passed into the succentric ventricle by the contractions of the external membrane of the crop, aided by a wide subcutaneous cervicle muscle which covers that reservoir.

In Pigeons, the crop is also present; but it is divided into two lateral pouches, and exhibits glandular eminences towards the common inferior opening of these sacs into the œsophagus (*aquiparous glands*). Singular changes are observed in the apparent structure of its walls in the male as well as in the female, from the eighth to the twentieth day of incubation, or during the first weeks after hatching, which coincide with the appearance of a kind of secretion which, when regurgitated, serves to nourish the young birds. At this period, the membranes of the crop become thickened; the vessels, more numerous and more apparent, are redder, and the glands more developed; the folds or ridges of the mucous membrane become more marked, and in their interspaces are deep depressions where an apparently milky fluid accumulates, and which is derived from the active proliferation of the epithelium and its concomitant fatty

[1] Cuvier, *Anatomie Comparée*. 2nd Edition. Paris: 1836.

degeneration. There are no permanent glands for this secretion.[1] Pigeons exclusively nourish their young with this fluid during the first three days of their existence.

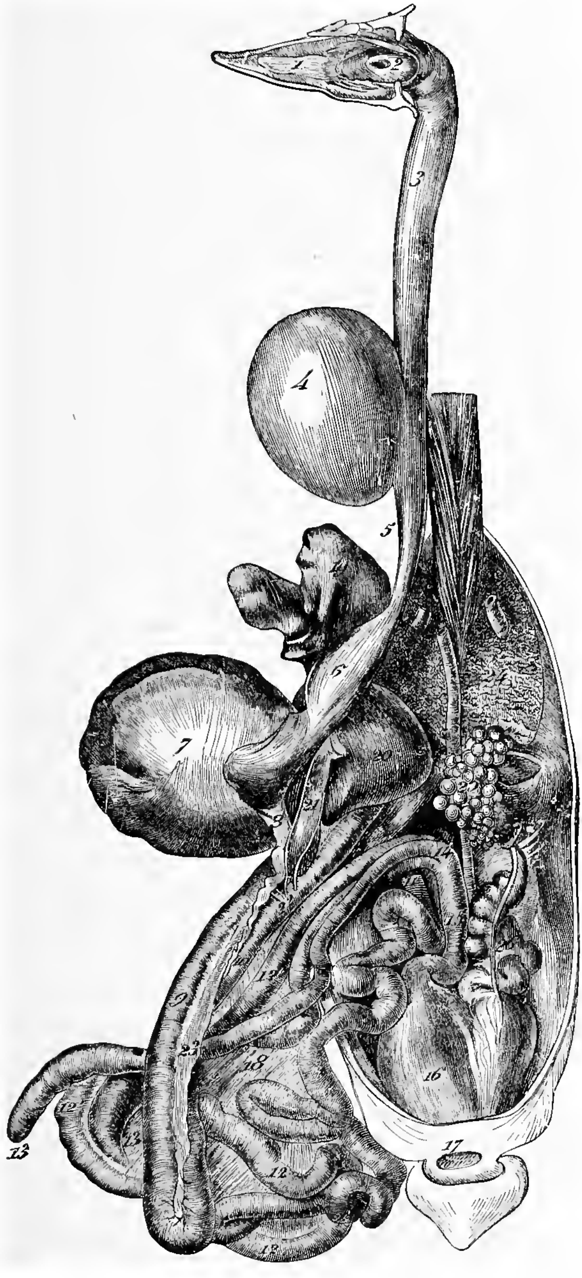


Fig. 305.

GENERAL VIEW OF THE DIGESTIVE APPARATUS OF A FOWL.

The abdominal muscles have been removed, as well as the sternum, heart, trachea, the greater portion of the neck, and all the head except the lower jaw, which has been turned aside to show the tongue, the pharynx, and the entrance to the larynx. The left lobe of the liver, succentric ventricle, gizzard, and intestinal mass, have been pushed to the right to exhibit the different portions of the alimentary canal, and to expose the ovary and oviduct.

1, Tongue; 2, pharynx; 3, first portion of the œsophagus; 4, crop; 5, second portion of the œsophagus; 6, succentric ventricle; 7, gizzard; 8, origin of the duodenum; 9, first branch of the duodenal flexure; 10, second branch of the same; 11, origin of the floating portion of the small intestine; 12, small intestine; 12′, terminal portion of this intestine, flanked on each side by the two cæca (regarded as the analogue of the colon of mammals); 13, 13, free extremities of the cæca; 14, insertion of these two *culs-de-sac* into the intestinal tube; 15, rectum; 16, cloaca; 17, anus; 18, mesentery; 19, left lobe of the liver; 20, right lobe; 21, gall-bladder; 22, insertion of the pancreatic and biliary ducts; the two pancreatic ducts are the anteriormost, the choledic or hepatic is in the middle, and the cystic duct is posterior; 23, pancreas; 24, diaphragmatic aspect of the lung; 25, ovary (in a state of atrophy); 26, oviduct.

[1] Hunter, *Observations on certain parts of the Animal Æconomy.* London: 1792. Duvernoy, in G. Cuvier, *Leçons d'Anatomie Comparée.* 2nd Edition. Paris: 1836. Charbonelle-Salle and Phisalix, *Sur la Secretion Lactée de Pigeons en Incubation,* in *Comptes Rendu de l'Academie des Sciences.* 1886.

STOMACH.—The stomach presents numerous variations in Birds. Its simplest form is seen in the Heron, Pelican, Petrels, etc., where it is a single sac provided with a thick zone of glands around the entrance of the œsophagus, which secrete the gastric juice. But in the majority of the other species, and particularly in our domesticated Birds, the disposition of the stomach is modified and complicated; the glandular zone destined for the gastric secretion forms a special compartment —the *succentric ventricle*, and this is followed by a second reservoir—the *gizzard*, which is remarkable for the strong muscular constitution of its walls. The first is also named the *glandular stomach*, and the second the *muscular stomach.*

Glandular stomach, or *succentric ventricle* (*proventriculus*) (Fig. 305, 6).—This is an ovoid sac placed in the median plane of the body, between the two lobes of the liver, and beneath the aorta. Its anterior extremity receives the insertion of the œsophagus; the posterior is continued by the gizzard. The volume of this stomach is inconsiderable, and its cavity is very narrow; the aliment does not accumulate in it, but merely passes through, carrying with it the acid juice which afterwards dissolves its protein elements. Its walls have three tunics: an external or peritoneal; a middle, formed of white muscular fibres, continuous with those of the œsophagus; and an internal, of a mucous nature, perforated by orifices for the passage of the gastric juice. These are small cylinders placed perpendicularly to the surface of the stomach, closely laid against one another, like the microscopic glands of Lieberkühn, and contained in the connective tissue layer uniting the inner to the middle tunic. The glandular structure of this receptacle caused it to be regarded as the true stomach in Birds; but Jobert has shown that the real gastric juice is secreted in the gizzard.

Gizzard or *muscular stomach* (*ventriculus bulbosus*) (Fig. 305, 7).—Much more voluminous than the preceding, this stomach is oval in form, depressed on each side, and situated behind the liver, being partly covered by the lateral lobes of that gland. Above, and to the right, and at a short distance from each other, are seen the insertion of the succentric ventricle and the origin of the duodenum. The cavity of the gizzard always contains food mixed with a large quantity of silicious pebbles, the use of which will be indicated hereafter.

This viscus is composed of the three tunics which form the walls of all the abdominal reservoirs. The internal, or mucous, is distinguished by the thickness and extraordinary induration of its epidermic layer, which presents nearly all the characters of horny tissue, and which results from the accumulation of the products secreted by the epithelium. The latter is spheroidal, and is so easily detached from the mucous chorium that it is often regarded as a special membrane. On the adherent face of this corium are applied two powerful red muscles—a superior and inferior, occupying the borders of the organ, and whose fibres, disposed in flexures, pass from side to side, and are inserted into a strong, nacrous aponeurosis on the lateral surfaces of the organ. Outside this contractile apparatus is a thin peritoneal envelope.

The gizzard is the triturating apparatus of Birds. When the aliment reaches its cavity it has not yet submitted to any disaggregation, but here it meets with all the conditions indispensable for the accomplishment of this act: two energetic compressor muscles, a corneous layer spread over the internal surface of the viscera, giving to it the rigidity necessary to resist the enormous pressure exercised on its contents; and silicious pebbles—veritable artificial teeth—which an admirable instinct causes Birds to swallow, and between which, by the effort of the triturating muscles, the food is bruised. This triturating action of the gizzard is only effected in Birds fed on hard coriaceous aliment, such as the various kinds of grain. It would be useless in Birds of prey, in which the two gizzard muscles are replaced by a thin fleshy membrane of uniform thickness—showing that the presence of these muscles is subordinate to the kind of alimentation.

INTESTINE.—The length of the intestine varies, as in Mammals, according to the nature of the food: very short in Birds of prey, it is notably elongated in omnivorous and granivorous Birds. Its diameter is nearly uniform throughout its whole extent, and it is difficult to establish in Birds the various distinctions recognized in the intestine of Mammalia. It begins by a portion curved in a loop, which represents the *duodenum*, the two branches of which, lying side by side, are parallel to each other, like the colic flexure of Solipeds. Fixed by a short mesenteric frænum to the colon, this part of the intestine includes the pancreas between its two branches. Its curvature floats freely in the pelvic portion of the abdominal cavity (Fig. 305, 8, 9, 10).

To the *duodenal loop* succeed convolutions suspended to the sublumbar parietes by a long mesentery, and which are rolled up into a single mass, elongated from before to behind, occupying a middle position between the air-sacs of the abdominal cavity. The analogy existing between this mass of convolutions, and the *floating portion of the small intestine* of Mammals, does not require demonstration (Fig. 305, 11, 12).

The terminal part of this floating intestine lies beside the duodenal loop, and is flanked by the two appendages disposed like *cæca*. These, scarcely marked in the **Pigeon** by two small tubercles placed on the track of the intestinal tube, do not measure less than from 6 to 10 inches in the other domesticated Birds; they are two narrow *culs-de-sac*, slightly club-shaped at their closed extremities, which are free and directed towards the origin of the intestine, while the other extremity opens into the intestinal canal near the anus. There are always alimentary matters in these sacs, these becoming introduced, in following a retrograde course, by the same almost unknown mechanism which presides over the accumulation of spermatic fluid in the vesiculæ seminales. According to the majority of naturalists, these two appendages, although described as *cæca*, do not represent the reservoir bearing that designation in Mammals. This reservoir is nothing more than a small special appendix placed on the track of the intestine, in front of the free extremity of the above-mentioned *culs-de-sac*, and is only to be found in a small number of Birds, and among these sometimes, as Gurlt[1] affirms, is the **Goose**. According to this view, which appears to be a very rational one, the portion of intestine comprised between the two blind tubes annexed to the viscera (Fig. 305, 12′) corresponds to the *colon*, and these tubes themselves are only dependencies of this intestine.

The *rectum* (Fig. 305, 15) terminates the digestive canal; it is the short portion of intestine that follows the opening of the cæca. Placed in the sublumbar region, this viscus is terminated by a dilatation, the cloaca (Fig. 305, 16), a vestibule common to the digestive and genito-urinary passages, which opens externally at the anus, lodges the penis when it exists, and serves as a confluent for the ureters, oviduct, bursa of Fabricius, and the deferent canals.

ABDOMINAL APPENDAGES OF THE DIGESTIVE CANAL.—*Liver* (Fig. 305, 19, 20).—This is a voluminous gland, divided into two principal lobes—a right and left, the former always larger than the latter; these incompletely include, on each side, the gizzard and succentric ventricle. In the **Pigeon**, this gland is

[1] Gurlt, *Op. cit.*

provided with a gall-bladder (Fig. 305, 21) attached to the internal face of the right lobe. But the arrangement of the excretory apparatus is not altogether identical with that observed in Mammals which possess this receptacle; as two biliary ducts open separately into the intestine towards the extremity of the second branch of the duodenal loop. One proceeding directly from the two lobes of the liver, is the *hepatic* or *choledic duct;* the other, the *cystic duct,* remains independent of the latter, and opens behind it. It carries into the digestive canal the bile accumulated in the gall-bladder, and which arrives there by a particular duct belonging exclusively to the right lobe; the cystic canal is a branch of this duct (Fig. 305, 22).

Pancreas (Fig. 305, 23).—In the *Gallinaceæ*, this gland is very developed, long, and narrow, and is comprised in the duodenal loop or flexure; at the extremity next the gizzard it has two principal excretory ducts, which separately pierce the intestinal membranes, a little in front of the hepatic duct.

Spleen.—This is a small, red-coloured, disc-shaped body, placed to the right of the stomachs, on the limit of the gizzard and succentric ventricle.

BOOK III.

Respiratory Apparatus.

The maintenance of life in animals not only requires the absorption of the organizable and nutritive matters conveyed to the internal surface of the digestive canal, but demands that another principle—the *oxygen* of the atmosphere—should enter with these materials into the circulation. In animals with red blood, this element, in mixing with the nutritive fluid, commences by expelling an excrementitial gas—*carbonic acid*—and communicating a bright red colour to that fluid, with which it circulates ; it is brought into contact, in the general capillary system, with the minute structures of the various apparatuses, exercising on the organic matter composing them a particular stimulating influence, without which the tissues could not manifest their properties, as well as inducing a combustible action which evolves the heat proper to the animal body.

This new absorption constitutes the phenomenon of respiration. In the Mammalia, this is effected in the *lungs*—parenchymatous organs chambered into a multitude of vesicular spaces, which receive the air and expel it, after depriving it of a certain quantity of oxygen, and giving, in return, a proportionate quantity of carbonic acid. These organs are lodged in the *thoracic cavity*, the alternate movements of dilatation and contraction of which they follow. They communicate with the external air by two series of canals placed end to end : 1. A *cartilaginous tube* originating in the pharyngeal vestibule, and ramifying in the lungs. 2. The *nasal cavities*, two fossæ opening into that vestibule, and commencing by two openings at the anterior extremity of the head.

CHAPTER I.

RESPIRATORY APPARATUS IN MAMMALIA.

In this apparatus we will first study the organs external to the thoracic cavity—the *nasal* cavities, and *larynx* and *trachea ;* then the chest and the organ it contains—the *lung.*

To this study will be added that of the two glandiform organs, the uses of which are unknown, but by their anatomical connections they belong to the respiratory apparatus. These are the *thyroid bodies* and the *thymus gland.*

The Nasal Cavities.

These cavities are two in number—a right and left—and offer for study: their entrance, or *nostrils*—the *fossæ*, properly called, which constitute these cavities; and the diverticuli named *sinuses*.

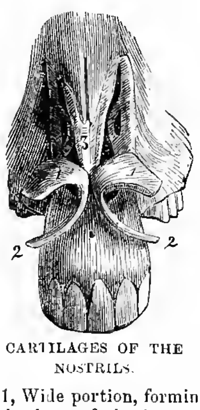
Preparation.—Remove the lower jaw from three heads. On the first of these make two transverse sections, one passing between the second and third molar tooth, the other behind the dental arch. Saw through the second head longitudinally and vertically, a little to one side of the median line. On the third make a horizontal section in such a manner as to obtain an inferior portion analogous to that shown in Fig. 41. On this the organ of Jacobson may be studied.

1. The Nostrils.

The *nostrils* (or *anterior* or *inferior nares*) are two oblong, lateral openings, situated at the extremity of the nose, circumscribed by *lips* or movable *wings* (*alæ*) disposed in an oblique direction downwards and inwards, and slightly curved on themselves, so as to present their concavity to the external side.

The *lips* or *alæ* of the nostril are enveloped, inwardly and outwardly, by a thin, delicate skin, covered by fine, short hairs. The *external* is concave on its free margin; the *internal* is convex. The *commissure* which unites these two wings superiorly, forms a slight arch curved inwards. When the finger is introduced into this commissure it does not enter the nasal cavity, but the *false nostril*—a conical pouch formed by the skin, extending to the angle comprised between the nasal spine and the ascending process of the premaxillary bone.

Fig. 306.



CARTILAGES OF THE NOSTRILS.

1, 1, Wide portion, forming the base of the internal wing of the nostril; 2, 2, narrow extremity prolonged into the external wing; 3, superior or anterior border of the nasal septum.

In the **Ass**, according to Goubaux, the false nostril is areolated at the posterior extremity, which ascends beyond the summit of the re-entering angle formed by the nasal and premaxillary prolongation.

The *inferior commissure* is round and wide, and, towards the bottom, presents an opening, sometimes double, which looks as if punched out; this is the inferior orifice of the lachrymal duct, which, in the **Ass** and **Mule**, is carried to the inner face of the external wing, near the superior commissure.

Structure.—The nostril is composed of a *cartilaginous framework*, *muscles* to move it, and *skin*, *vessels*, and *nerves*.

Cartilaginous framework (Fig. 306).—This framework is formed by a cartilage, bent like a comma, and which, in its middle part, lies against that of the opposite side, the two making a kind of figure X. Fixed in a movable manner to the inferior extremity of the middle septum of the nose, by means of short interposed fibres, this cartilage offers: a wide upper part, situated in the substance of the inner wing of the nostril, and covered by the dilatator naris transversalis of the nose (Fig. 306, 1); and an inferior portion, which, after passing into the lower commissure, is prolonged, in a blunt point, to the external wing, where it receives the insertion of several fasciculi belonging to the orbicularis muscle of the lips, the dilatator naris lateralis, and the levator labii superioris (Fig. 306, 2). Each wing, therefore, possesses its cartilaginous skeleton; but that of the external wing is very incomplete, in consequence of its being only formed by the inferior extremity of the common cartilage.

These cartilages, it will be understood, sustain the alæ of the nose, prevent their falling inwards, and always keep open the external orifices of the respiratory apparatus.

Muscles.—The motor muscles of the alæ are all dilators in the domesticated animals. They are: the *tranversalis dilatator naris*, a single muscle placed on the widened portions of the cartilages; the *dilatator naris lateralis*, the insertion of which occupies the whole extent of the external wing; the *dilatator naris superior*, fixed, by its two portions, to the skin of the false nostril; the *dilatator naris inferior*, which is confounded, superiorly, with the external fasciculus of the preceding muscle, it being attached to the inferior branch of the cartilaginous appendix of the supermaxillary turbinated bone; and, lastly, the *levator labii superioris alæque nasi*, the anterior branch of which is inserted, in part, into the external wing. All these muscles, having been described in the Myology (p. 278), need not be further alluded to here.

Skin of the nose.—The skin covering the alæ of the nose, externally, is doubled over their free margin to line their internal surface, being prolonged over the entire extent of the false nostril, and is continued in the nasal fossæ, by the properly so called pituitary membrane. This skin is fine, thin, charged with colouring pigment, often marked by leprous spots, and adheres closely to the muscles included between its duplicatures, through the medium of a very dense, resisting, connective tissue.

Vessels and nerves.—The nostrils are supplied with blood by the *superior coronary*, the *external nasal*, and the *palato-labial arteries*; it is returned by the *glosso-facial veins*, and partly by the venous network of the nasal mucous membrane. The *lymphatics*, large and abundant, receive those of the pituitary membrane, and join the submaxillary glands by passing over the cheeks. The *nerves* are very numerous, the sensory being derived from the maxillary branch of the fifth pair, and the motors from the facial nerve.

FUNCTIONS.—The nostrils permit the entrance to the nasal cavities, of the air which is to pass to the lungs. Their dilatability allows the admission of a greater or less volume, according to the demands of respiration. It is to be remarked that, in Solipeds, the nostrils are the only channel by which the air can gain access to the trachea, in consequence of the great development of the soft palate, which is opposed to its entrance by the mouth; these orifices are therefore, for this reason, relatively larger than in the other domesticated animals, in which the passage of air by the buccal cavity is easily accomplished.

2. THE NASAL FOSSÆ (Figs. 306, 307, 308).

Channeled in the substance of the head, above and in front of the palate, and separated from one another, in the median plane, by a cartilaginous septum which does not exist in the skeleton, the nasal fossæ extend from the nostrils to the cribriform plate of the ethmoid bone, in a direction parallel to the larger axis of the head. Their length is, therefore, exactly measured by that of the face (see Fig. 308 for the whole of these cavities).

The nasal fossæ are formed by *two lateral walls*, a *roof* or *arch*, a *floor*, and *two extremities*.

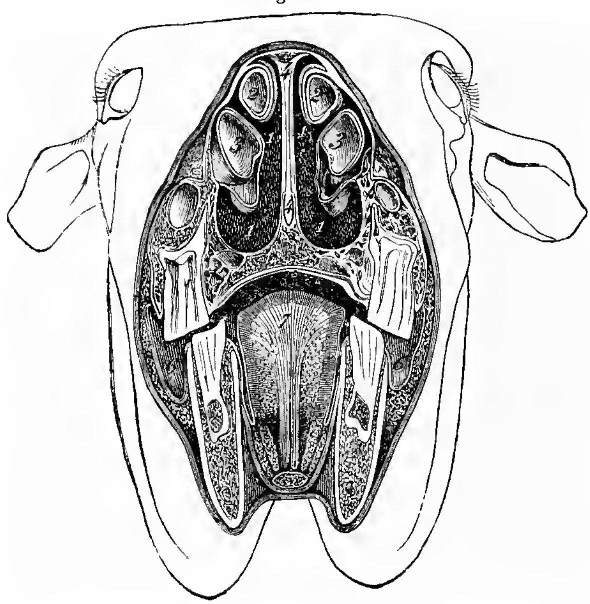
Walls.—The two walls are very close to each other, and the more so as they are examined towards the ethmoid bone and the roof of the cavity. The space separating them varies, in proportion as it is measured at the turbinated bones or at the meatuses.

Inner wall.—This is formed by the nasal septum, and is perfectly smooth.

Outer wall.—This is chiefly constituted by the supermaxillary bone; it is very rugged, and is divided into three *meatuses*, or passages, by the turbinated bones—the irregular columns applied against the inner face of the before-mentioned bone.

The *turbinated bones* have already been described (p. 73), and we will only now refer to the principal features in their arrangement. Each is a bony plate rolled upon itself (Fig. 307, 2, 3), and divided, internally, into two sections, *the superior of which forms part of the sinus, and the inferior belongs to the nasal fossa;* they are continued, inferiorly, by a fibro-cartilaginous framework, which prolongs

Fig. 307.



TRANSVERSE SECTION OF THE HEAD OF AN OLD HORSE, SHOWING THE ARRANGEMENT OF THE NASAL CAVITIES AND MOUTH.

1, 1, Nasal fossæ; 2, superior turbinated bone, 3, inferior ditto; 4, median septum of the nose; 5, central part of the buccal cavity (drawn more spacious than it really is when the two jaws are brought together); 6, 6, lateral portions of the same; 7, section of the tongue, showing it filling the lingual canal.

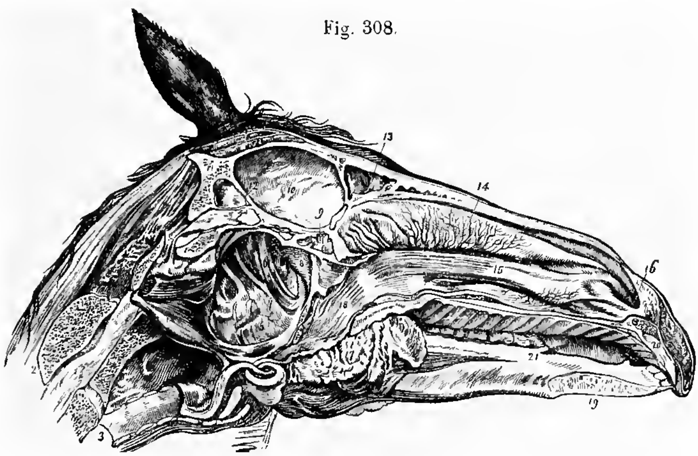
their nasal section to the external orifice of the nose. The flexible appendage of the ethmoidal turbinated bone is usually single, sometimes double, and disappears before reaching the alæ of the nose. That of the premaxillary turbinated bone is always bifurcated, and its antero-superior branch is directly continued by the superior extremity of the internal wing of the nostril.

The *meatuses* are distinguished into *superior*, *middle*, and *inferior*, or into *anterior*, *middle*, and *posterior*, as the head is inspected in a vertical or horizontal position. The *superior* passes along the corresponding border of the ethmoidal turbinated bone, and is confounded with the roof of the nasal cavity; it is prolonged, behind, to near the cribriform plate of the ethmoid bone, and is the narrowest. The *middle*, comprised between the two turbinated bones, presents, on arriving near the ethmoidal cells, the orifice that brings all the sinuses into communication with the nasal fossa. This orifice is ordinarily narrow and curved; but we have seen it sometimes converted into a foramen sufficiently wide to permit the introduction of a finger-end. It is also by this meatus that the inferior compartment of the turbinated bones opens into the nasal fossa, these two bones being each rolled in a contrary direction. The *inferior meatus*, situated under the maxillary turbinated bone, is not distinct from the floor of the nasal cavity (see Fig. 307 for the arrangement of the turbinated bones and the meatuses on the external wall of the nose).

Roof or arch.—This is formed by the nasal bone, and is only a narrow channel, confounded, as has been said, with the superior meatus.

Floor.—Wider, but not so long as the roof, which is opposite to it, and from which it is distant by the height of the cartilaginous septum, the floor is concave

Fig. 308.



LONGITUDINAL MEDIAN SECTION OF THE HEAD AND UPPER PART OF THE NECK.

1, 1, Atlas; 2, 2, dentata; 3, trachea; 4, right stylo-thyroideus; 5, guttural pouch; 6, stylo-pharyngeus; 8, palato-pharyngeus; 9, sphenoidal sinus; 10, cranial cavity; 11, occiput; 12, parietal protuberance; 13, frontal sinus; 14, ethmoidal turbinated bone; 15, premaxillary turbinated bone; 16, entrance to nostril; 18, pharyngeal cavity; 19, inferior maxilla; 20, premaxilla; 21, hard palate.

from one wall to the other, and rests on the palatine arch, which separates the mouth from the nasal cavities.

In front of this nasal region is remarked the *canal* or *organ of Jacobson*—a short duct terminating in a *cul-de-sac* in the middle of the cartilaginous substance which closes the incisive foramen. At the bottom of this *cul-de-sac* opens a second canal, longer, wider, and more remarkable, but which has not yet been described. (It has been described by Steno, and is named "Steno's canal.") It has sometimes the diameter of a writing-quill, commences by a *cul-de-sac* at the level of the second molar tooth, and accompanies the inferior border of the vomer from behind to before, where it is enveloped in a kind of cartilaginous sheath—a dependency of the nasal septum; it terminates, as we have said, after a course of about 5 inches.

The structure of Jacobson's organ resembles that of the excretory duct of glands; its walls are evidently composed of two tunics—an internal or mucous, very rich in follicles, and having longitudinal folds ; and an external, of a fibrous nature. These membranes receive numerous vessels, as well as nerves emanating from a long filament of the spheno-palatine ganglion, and which may be traced from the external side of the canal to near the incisive foramen, where it is lost. Such is the organ of Jacobson ; its uses are quite unknown. (It belongs to the olfactory region, for between the ciliated cells of its mucous membrane are found staff-like cells, which are connected with the ends of the olfactory nerve-filaments.)

Extremities.—The *anterior* or *inferior extremity* of the nasal fossa (*regio vestibularis*) is formed by the nostril already described. The *posterior* or *superior extremity* presents, above, a space occupied by the ethmoidal cells. Below and behind, this extremity communicates with the pharyngeal cavity by a wide oval opening, which is circumscribed by the vomer and palate bones : this is the guttural opening of the nasal fossa (or *posterior nares*).

STRUCTURE.—The nasal fossæ offer for study : 1. The *bony framework* by which these cavities are formed. 2. The *cartilaginous septum* separating them. 3. The *pituitary membrane*—the mucous layer lining their walls.

1. **Bony Framework of the Nasal Fossæ.**—This comprises : 1. The *nasal*, *maxillary*, *frontal*, and *palate bones*, which together form a vast irregular wall circumscribing the nasal fossæ. 2. The *ethmoid bone*, occupying the bottom of this tubular cavity, and the *turbinated bones* applied against the lateral walls. 3. The *vomer*, placed in the median plane, and serving as a support for the cartilaginous partition dividing this single cavity into two compartments. All these bones having been already studied in detail, we confine ourselves to their simple enumeration.

2. **Middle Septum of the Nose** (*septum nasi*) (Fig. 307, 4).—Formed of cartilage susceptible of ossification, this partition is nothing more than the perpendicular lamina of the ethmoid bone prolonged to the extremity of the nose. Its elongated form permits us to recognize in it *two faces*, *two borders*, and *two extremities*. The *faces* are channeled by a multitude of furrows, which lodge the anastomosing vessels of the magnificent venous plexus of the pituitary membrane.

The *superior border*, united to the frontal bone and median suture of the nasal bones, expands to the right and left on the inner faces of these, in forming two laminæ, thin at their free margin, the section of which is represented in Fig. 307. These laminæ are wide enough in front to project beyond the nasal spine. The *inferior border* is received into the mortice of the vomer.

The *posterior extremity* is continued without any precise limitation, by the perpendicular lamina of the ethmoid bone.

The *anterior extremity*, a little wider, supports the cartilages of the nostrils. It is joined, below, to the premaxillary bones, and is spread out on the incisive openings in a thick layer which exactly closes them.

This septum is covered by a thick perichondrium, which adheres intimately to the pituitary membrane.

3. **Pituitary Membrane.**—This membrane—also designated the *olfactory mucous membrane*, and *Schneiderian membrane*—is continuous with the skin lining the inner face of the alæ of the nose. Examined on the internal wall of the nasal fossæ, the pituitary membrane is seen to cover the cartilaginous septum forming this wall, then spreads over the floor as well as the roof of the cavity, reaching the outer wall, which it also covers in enveloping the external surface of the turbinated bones, and is insinuated, by the middle meatus, into the cells

of the inferior or anterior compartment of these osteo-cartilaginous columns. It also penetrates, by the semicircular opening of this meatus, into the sinus, to give it its mucous lining, and is likewise prolonged into the canal of Jacobson. Behind, it is continuous with the lining membrane of the pharyngeal cavity.

Its deep face is separated by the periosteum or perichondrium, from the bony or cartilaginous walls on which it is spread ; and it is united to the two precited layers, this union being closest where it is thinnest, although it can always be easily distinguished from them throughout the whole extent of the nasal fossa. The free, or superficial face, presents numerous glandular orifices, and is constantly covered by an abundance of mucus, that prevents the desiccation to which this surface is exposed by the incessant movement of air over it.

STRUCTURE.—The organization of the pituitary membrane resembles that of other mucous membranes, but it also presents some differences according as it is examined near the nostrils or deeper in the cavities. It is also usual to divide it into two portions—the *olfactory mucous membrane*, which covers the upper part of the ethmoidal turbinated bone and cells ; and the *Schneiderian membrane*, lining the inferior two-thirds of the nasal cavities.

Fig. 309.

CELLS OF THE OLFACTORY MUCOUS MEMBRANE.

a, b, c, After Schultze; *d, e, f,* after Lockhart Clarke.

The *corium* (*tunica propria*) of the *Schneiderian membrane* (*regio respiratoria*) is thick, soft, spongy, and rose-coloured, and contains a large number of vessels and *glands*. The latter are mucus or racemose glands, and are extremely abundant in the layer covering the septum of the nose, as well as at the inner face of the cartilaginous appendages of the turbinated bones ; though they are rare or altogether absent on the external face of the latter. The *epithelium* is *ciliated* and *stratified*, the deeper cells being spherical, those on the surface cylindrical.

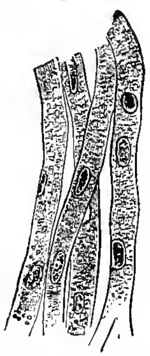
The *olfactory mucous membrane* (*regio olfactoria*) differs from the preceding by its greater thinness, its delicateness, its slightly yellow tint, and the character of its epithelium. The *corium* (*tunica propria*) contains straight or slightly convoluted *tubular glands*—the glands of Bowman. The *epithelium* is *columnar* and *stratified*, and readily alters ; in animals it is destitute of cilia. The deeper cells contain some yellowish pigment granules. Schultze describes as *olfactory cells*, certain fusiform elements which he considers are concerned in olfaction. These cells have two prolongations—a deep one, which is connected with the fibres of the olfactory nerve ; and a superficial, that enters between the epithelial cells, and tends to approach the free surface of the membrane.

(The "olfactory cells" are thin, rod-like bodies (Fig. 309, *b*), presenting varicose enlargements which are connected with processes of deeper-seated nerve-cells. The epithelial cylinders proper (*d, e*) are related at their bases with the septa of connective tissue belonging to the sub-epithelial glandular layer, and are probably in communication with the olfactory cell. Schultze describes another set of epithelial cells (*a*) as terminating externally by truncated flat surfaces, and to all appearance not covered by any membrane, apart from the contents of the cell, which are yellow, granular protoplasm, surrounding an oval nucleus lying in colourless protoplasm. The extremity of these cells is thin, and they can be traced inwards until they expand into a flat portion that sends off processes, which appear to be continuous with the fibres of the submucous connective tissue. Similar cells (*c*) are found towards the margin of the true olfactory region, but these have a band at their free extremity, which is also provided with a circle of cilia.)

The pituitary membrane receives its blood by the *ophthalmic* and *nasal arteries*; it is returned by the large anastomosing *veins* which form—in the deep layer—a long, close, and magnificent plexus that terminates in the satellite vein of the nasal artery. This plexuous arrangement is so marked at certain points—as at the appendages of the turbinated bones—that it gives the mucous membrane somewhat the appearance of erectile tissue. It will be understood that in favouring the stagnation of the blood, this arrangement predisposes to hæmorrhage.

The *lymphatics* of the pituitary membrane could not be injected for a long time, neither in Man nor animals; and this led several anatomists to deny their existence. Nevertheless, they do exist, and form a fine superficial network on the septum of the nose, the turbinated bones, and the meatuses. The trunks passing from this network go to the submaxillary glands.

Fig. 310.



FIBRES OF ULTIMATE RAMIFICATIONS OF OLFACTORY NERVE OF DOG.

The *nerves* of this membrane are numerous, and are derived from the first and fifth pairs, and from Meckel's ganglion. The ramifications of the olfactory nerve, on emerging from the apertures of the cribriform plate of the ethmoid bone, pass to the inner and outer walls of the nasal cavities; being destined for the olfactory mucous membrane, they do not descend below the upper third of these cavities. They form at first a close plexus, and afterwards terminate in a manner not quite understood. Schultze admits that they terminate on the olfactory cells mentioned above.

The branches derived from Meckel's ganglion and the fifth pair, are specially destined for the Schneiderian membrane, and are named the ethmoidal branches of the palpebronasal and spheno-palatine nerves. They endow the nose with an acute degree of sensibility, and it is believed that they render olfaction more perfect.

(It is to be remarked that the filaments composing the olfactory plexus, differ from ordinary cranial nerves in containing no white substance of Schwann, and are nucleated and finely granular in texture, resembling the gelatinous form of nerve-fibres. The surface to which they are limited is that covered with the yellowish-brown epithelium.)

3. The Sinuses.

The *sinuses* are very winding cavities, excavated in the substance of the bones of the head, on the limits of the cranium and face, and around the ethmoidal masses, which they envelop.

These cavities—diverticuli of the nasal fossæ—are pairs, and are five on each side, arranged in two groups: 1. The *frontal*, *supermaxillary*, *sphenoidal*, *ethmoidal sinuses*. 2. The *inferior maxillary sinus*. The first four communicate; the last is usually perfectly isolated.

First Group.

Frontal Sinus.—This cavity, situated at the inner side of the orbit, presents very irregular walls, which are formed by the frontal, nasal, lachrymal, and ethmoid bones, and the superior portion of the ethmoidal turbinated bone. It communicates with the superior maxillary sinus by a vast opening, made in a very thin bony partition. A thick vertical plate, often bent to the right or left, but always imperforate, separates this sinus from that of the opposite side.

Superior Maxillary Sinus.—Channeled beneath the orbit, between the maxillary, malar, ethmoid, and lachrymal bones, this diverticulum is the largest of all, and is divided into two great compartments by the maxillo-dental canal, which traverses it. The internal compartment is a kind of shallow cavity, continuous with the sphenoidal sinus, and presents a narrow slit, which opens into the ethmoidal sinus. The external compartment is separated, in front, from the maxillary sinus, by a partition which Goubaux has, contrary to the generally received opinion, demonstrated to be imperforate at all periods of life; though he has sometimes found it so thin as only to consist of two layers of mucous membrane laid against each other. This compartment is prolonged backwards into the maxillary protuberance, and the roots of the two last molars project into its interior.

Sphenoidal Sinus.—This is the smallest, after that of the great ethmoidal cell. Formed by the sphenoid and palatine bones, this cavity is very irregular, and is subdivided by incomplete septa into several compartments, which may be always reduced to two—an anterior, comprised between the palatine laminæ; and a posterior, in the body of the sphenoid bone. In contact, on the median line, with the sinus of the opposite side, it is separated from it by a twisted plate, which is constantly perforated, even in young animals.

Ethmoidal Sinus.—This is a cavity in the large ethmoidal cell; it constitutes a real sinus, and has a narrow slit which brings it into communication with the superior maxillary sinus.

Second Group.

Inferior Maxillary Sinus.—This last diverticulum is remarkable, because of its not communicating with the others. Excavated in the supermaxillary bone, and separated from the superior sinus by the imperforate septum previously mentioned, it is divided, like the latter cavity, into two compartments—an internal, prolonged into the superior cavity of the supermaxillary turbinated bones; and an external—the smallest—showing the roots of the fourth molar, rarely those of the third. It does not descend, as Rigot has asserted, above the three anterior molars; supposing the head to be vertical, it does not extend, in the adult Horse, beyond the extremity of the maxillary ridge, in front of which it would be necessary to trephine, in order to reach it. It is sometimes larger on one side than the other.

The inferior maxillary sinus, in the **Ass**, communicates with the superior maxillary sinus. "These two parts of the maxillary sinus, or the two maxillary sinuses," says Goubaux, "always communicate largely with each other in the Ass. I have never seen an exception to this; and the peculiarity is due to the fact, that the base or posterior extremity of the inferior turbinated bone is checked in its development, and does not curve sufficiently to join the inner surface of the supermaxilla, and become attached thereto."

Communicating Orifice of the Sinuses with the Nasal Fossa.—All the sinuses of one side communicate with the corresponding nasal fossa, by the curved slit at the bottom of the middle meatus. This slit penetrates the superior maxillary sinus, under the septum that separates it from the frontal sinus; it also enters the inferior maxillary sinus, which thus communicates solely with the nasal cavity, while the other diverticuli open in common into this cavity, through the medium of the superior maxillary sinus.

Mucous Membrane of the Sinuses.—In entering the sinuses to cover their walls, the pituitary membrane becomes extremely thin, and loses its great vascularity; it is applied immediately to the bones, and serves as a periosteum. It has some nerves which terminate in small bell-shaped organs (Inzani).

Development of the Sinuses.—These cavities begin to be developed in the fœtus, and are gradually formed in the thickness of the bones they occupy. They increase during the animal's lifetime, by the thinning of the bony plates enclosing or partitioning them, and particularly by the growth of the superior molar teeth, the roots of which project into them. The formation of the inferior maxillary sinus is more tardy than the others; though it is not so late as seven or eight years, as the majority of Veterinary Anatomists have asserted. Goubaux has proved that the sinus is already present in a six-months-old animal; and in a head which has been for several years in the museum of the Lyons School, and which belonged to a foal of very small stature, about a year old, this sinus is found, in its external part, to be already $1\frac{1}{2}$ inches in depth, and $\frac{8}{10}$ of an inch in width.

Functions of the Sinuses.—Have the sinuses or diverticuli of the nasal cavities, the same uses as these cavities? It is probable, although not absolutely certain. There is nothing to prove that they have anything to do with respiration or olfaction; and it would seem that their exclusive function is to give increased volume to the head without increasing its weight, and in this way to furnish wide surfaces of attachment for the muscles belonging to this region—these cavities being all the more ample as the muscles are large and numerous.

Differential Characters in the Nasal Cavities of the other Animals.

1. *Nostrils.*—In the **Ox**, the nostrils, placed on each side of the muffle, are narrower and less movable than in the Horse. (The superior extremity of the ala is not horizontal; the inferior is divided into two branches.)

In the **Pig**, the end of the nose constitutes the snout (*rostrum suis*), the anterior surface of which, plane and orbicular, shows the external orifices of the nostrils. This *snout*— a veritable tactile organ employed by the animal to dig up the ground—is covered by a dark-coloured skin, kept damp by a humid secretion, like the muffle of the Ox. It has for base the *scooping-bone*—a particular piece situated at the extremity of the nasal septum, and enveloped by a layer of cartilage that extends around the nostrils. It is easy to distinguish two symmetrical halves in this bone, which evidently represent the two cartilages in the nose of Solipeds.

In the **Dog**, the end of the nose forms a salient region, which is roughened, naked, usually dark-coloured, damp, and sometimes divided by a median groove; in this region the nostrils are placed, their form resembling two commas opposed to each other by their convexities. The cartilaginous framework sustaining these orifices is not composed of separate pieces, but is only a dependency of the median septum and the appendages of the turbinated bones.

The same considerations apply to the nostrils of the **Cat**, with the exception of the colour of the integument, which is nearly always of a rosy hue, like the mucous surfaces.

2. *Nasal Cavities.*—The nasal fossæ of the **Ox**, **Sheep**, and **Goat**, are distinguished by the presence of a third turbinated bone—the *olfactory antrum*, and by the communication existing between them, posteriorly, above the inferior border of the vomer. We have already seen that in these animals, as in those yet to be mentioned, the canal of Jacobson passes completely through the palatine arch.

In the **Pig**, the nasal fossæ are long and narrow. They are, on the contrary, very short in the **Dog** and **Cat**, and the internal cells of the turbinated bones, remarkable for their number and complexity, all communicate with the proper nasal fossæ, without concurring in the formation of the sinuses. The latter are divided by the vomer into two superposed compartments, very distinct from each other in their posterior half; the superior is olfactory, the inferior is respiratory.

3. *Sinuses.*—In the **Ox**, the *frontal sinuses* are prolonged into the bony cores which support the horns, and into the parietal and occipital bones; they therefore envelop, in a most complete manner, the anterior and superior part of the cranium, and form a double wall to this bony cavity. They are extremely diverticulated, and do not communicate with those of the supermaxillary bones. They usually open, on each side, into the nasal cavities, by four apertures at the base of the great ethmoidal cell. According to Girard, three of these orifices lead to special compartments, isolated from one another, and grouped around the orbit, in consequence of which these diverticuli of the frontal sinuses are designated the *orbital sinuses.*

This author has denied the presence of *sphenoidal sinuses;* but they exist, although small, and are in communication with the preceding.

The *sinus of the great ethmoidal cell* comports itself as in the Horse.

There is only one pair of *maxillary sinuses*, which are very large, and partitioned into two compartments by a plate of bone; this bears at its superior border the supermaxillo-dental canal, like the superior maxillary sinus of Solipeds. The external or maxillary compartment, is prolonged into the lachrymal protuberance; the internal occupies the substance of the palatine arch. A wide orifice at the base of the maxillary turbinated bone affords communication between this sinus and the nasal fossa.

In the **Sheep** and **Goat,** there exists a similar arrangement in the sinuses of the head; but these cavities are much less spacious than in the Ox; the frontal sinus, in particular, does not extend beyond the superior border of the frontal bone.

In the **Pig,** these latter sinuses are prolonged into the parietal bones; though they are far from offering the same extent as in the smaller Ruminants. It is the same with the others; they present an arrangement analogous to those of the Sheep and Goat.

In the **Dog** and **Cat,** there are only, on each side, a maxillary and a frontal sinus. The first scarcely merits notice· and the second, a little more developed, opens into the nasal cavity by means of a small aperture situated near the middle septum of the two frontal sinuses.

(Leyh states that the Carnivora have no maxillary sinus; consequently, the *sphenoidal sinus* communicates below with the nasal fossæ.)

Comparison of the Nasal Cavities in Man with those of Animals.

The external orifices of the nasal cavities of *Man* are called *nostrils;* these are flattened transversely, and prolonged in front of the lobule of the nose; their external face, or ala, is concave and movable. They are lined internally by a membrane that holds a middle place between the skin and mucous membranes; it has a number of little hairs, called *vibrissæ.*

The *cavities* or *nasal fossæ* offer nothing particular; as in animals, they show a superior, middle, and inferior meatus. On their floor, in front, is seen the superior orifice of the incisive foramen, which corresponds to the commencement of Jacobson's canal. The *pituitary membrane* has a squamous epithelium in its olfactory, as on its Schneiderian portion. At the bottom of the nasal cavities and the upper part of the pharynx, is a kind of diverticulum named the *posterior nares;* it has been already alluded to when speaking of the pharynx.

The *sinuses* are: 1. The sphenoidal sinus and the posterior ethmoidal cells, that open beneath the roof of the nasal fossæ. 2. The middle ethmoidal cells, opening into the superior meatus. 3. The anterior ethmoidal cells, and frontal and maxillary sinuses, communicating with the middle meatus. All these sinuses have a proper communicating orifice with the nasal cavities.

The Air-tube succeeding the Nasal Cavities.

This single tube comprises: the *larynx*, which commences the *trachea;* the latter forms the body or middle portion, the *bronchi* terminating it.

1. Larynx (Figs. 308, 311, 312, 313, 314).

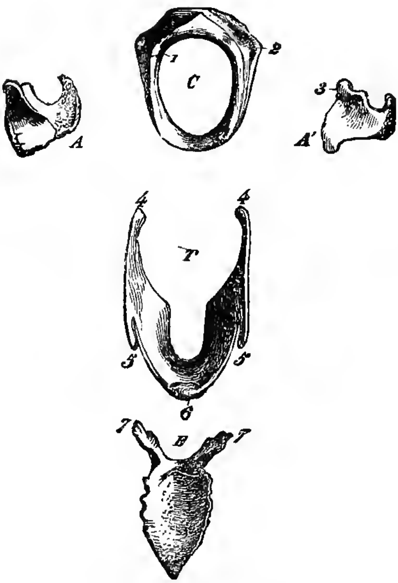
Preparation.—1. Make a longitudinal section of the head, in order to study the general arrangement of the larynx (Fig. 308). 2. Isolate the cartilages, to examine their external conformation. 3. Remove the muscles from a third larynx, to show the mode of articulation of the various cartilages (Figs. 312, 314). 4. Prepare the muscles in conformity with the indications furnished by a glance at Fig. 314. 5. Remove a larynx as carefully as possible, so as not to injure the walls of the pharynx, in order to study the interior of the organ, and especially its pharyngeal opening (Fig. 315).

Form—Situation.—The *larynx* forms a very short canal, which gives admission to the air during respiration, and is at the same time the organ of the voice.

It is a cartilaginous box, flattened on each side, and open from one end to the other: the anterior orifice being situated at the bottom of the pharyngeal cavity, and the posterior continuous with the trachea.

This apparatus, situated in the intra-maxillary space, is suspended between the two cornua of the os hyoides, and fixed to the extremities of these appendages by one of its constituent pieces. It supports the pharynx, and by means of the walls of the latter is attached to the circumference of the posterior openings of the nasal cavities.

Fig. 311.



CARTILAGES OF THE LARYNX DISARTICULATED.

C, *Anterior surface of the cricoid:* 1, facet for the arytænoid; 2, facet for the thyroid. A, *External surface of the arytænoid.* A', *ibid.*, internal surface: 3, facet for the cricoid. T, *Thyroid, seen from above:* 4, 4, posterior extremities of its wings; 5, appendages for the hyoid cornua; 6, body of the thyroid. F, *Epiglottis, supero-posterior surface:* 7, 7, prolongations forming the supposed superior vocal cords.

In order to facilitate description, this brief notice of its form, situation, general relations, and mode of attachment will be followed by a notice of its structure; afterwards, the study of its external and internal surfaces will receive attention.

STRUCTURE OF THE LARYNX.—It comprises in its structure: 1. A *cartilaginous framework*, composed of five pieces. 2. *Muscles*, which move these pieces. 3. A *mucous membrane* spread over the inner surface of the organ. 4. *Vessels* and *nerves*.

1. *Cartilaginous framework of the larynx.*—In this we find: three single median cartilages—the *cricoid*, *thyroid*, and *epiglottis*; and two lateral cartilages, the *arytænoid*. All are movable, one upon the other.

Cricoid Cartilage (Fig. 311, C).—This cartilage, as its name indicates (κρίκος, εἶδος, "like a ring"), is exactly like a ring with a bezel placed upwards. Depressed on each side, but all the less as the animal has its respiratory apparatus well developed, this ring offers *two faces*, and *two borders* or *circumferences*. The *internal face* is smooth, and covered by mucous membrane. The *external face* is provided, in the middle of the widened portion forming the bezel, with a little eminence more or less prominent, elongated in the form of a crest, and separating the two posterior crico-arytænoid muscles (to which it gives attachment) from each other. On the sides of this bezel are two small, articular, concave facets, which correspond to the branches of the thyroid cartilage. Nothing remarkable is to be noted for the remainder of the extent of this face. The *superior circum-*

ference, comprised laterally between the two branches of the thyroid cartilage, is concave in the narrow part opposite the bezel, where it shows two lateral convex articular facets for articulation with the arytænoid cartilages. The *inferior circumference* is related to the first ring of the trachea; it has a small notch, often double, on the middle of the bezel.

Thyroid Cartilage (θυρεός, εἶδος, "like a shield") (Fig. 311, T).—This is composed of two lateral plates, which have the form of an obliquangular parallelogram, and are united at their anterior extremity to form a thick constricted part which, in Veterinary Anatomy, is named the *body of the thyroid.* This *body* is smooth on its *inferior face*, where it is covered by the terminal extremities of the subscapulo-hyoideii muscles. On its *superior face* is an obtuse, rounded, and irregular protuberance, on which the epiglottis articulates.

The *plates*, *lateral branches*, or *alæ* of the thyroid, present *two faces*, *two borders*, and *two extremities*. The *external* face, slightly convex, is covered by the hyo-thyroideus and thyro-pharyngeus muscles. The *internal face*, slightly concave, is covered, near the superior border, by the pharyngeal mucous membrane; for the remainder of its extent it is in contact with the thyro-arytænoid and lateral crico-arytænoid muscles.

The *superior border* is divided by a small prolongation into two parts—an anterior, giving attachment to the thyro-hyoid membrane; the other posterior, into which is inserted the palato-pharyngeus muscle. This appendix—the *great thyroid cornu* of Man—forms one of the obtuse angles of the parallelogram represented by each lateral plate of the thyroid cartilage; it is united to the extremity of the hyoid cornu; and at its base is an opening, or deep notch, through which passes the superior laryngeal nerve. The *inferior border* is also divided into two parts by the second obtuse angle of the cartilage: the anterior part forms, with that of the opposite plate, a receding angle occupied by the crico-thyroid membrane (*ligamentum crico-thyroideum medium*); the posterior gives attachment to the crico-thyroid muscle. The *extremities* constitute the acute angles of the thyroid plate. The *anterior* joins that of the opposite branch, to form the body of the cartilage. The *posterior*, slightly curved downwards, is terminated by a small, convex, diarthrodial facet, which articulates with the concave facets on the external face of the cricoid cartilage.

The thyroid cartilage is frequently partially, or even entirely, ossified.

Epiglottis (Fig. 311, E).—This is a soft and flexible appendage, shaped like a sage-leaf; inferiorly, it circumscribes the entrance to the larynx, and is bent over it, so as to close it hermetically when the alimentary bolus is traversing the pharyngeal vestibule.

This cartilage has *two faces*, *two lateral borders*, a *base*, and a *summit*. The *anterior face* is convex from side to side, concave from above to below, and covered by the mucous membrane of the pharynx: it gives attachment to the hyo-epiglottidean muscle.

The *posterior face* shows an inverse configuration, and is covered by the lining membrane of the larynx, which is perforated by glandular orifices. The *borders* offer a free portion, which aids in circumscribing the entrance to the larynx; as well as an adherent part fixed to the arytænoid cartilage by means of a mucous fold, and made irregular by the little cartilaginous bodies which are superadded to it. (These are the *cuneiform cartilages*, or *cartilages of Wrisberg*, placed in the arytæno-epiglottidean fold of mucous membrane, which extends from the apex of the arytænoid cartilage to the side of the epiglottis.) The *base* is thick, and articulates with the middle part of the thyroid; it gives origin, posteriorly, to two lateral prolongations, which pass to the inferior border of the arytænoids, but usually without joining these.

The *summit* unites the free portion of both borders, and is thrown forwards on the upper face of the soft palate.

Arytænoid Cartilages (Fig. 311, A, A′). These two pieces have been so designated from their resemblance, when approximated, to the mouth of a pitcher (*ἀρύταινα, εἶδος*, "like a pitcher"). They are situated in front of the cricoid, above the entrance to the larynx; each has an irregular quadrilateral form, and presents for study *two faces* and *four borders*. The *internal face* is smooth, almost flat, and lined by the laryngeal mucous membrane. The *external* face is divided by a ridge into two portions: a superior, covered by the arytænoid muscle; and an inferior, giving attachment to the thyro-arytænoid and lateral crico-arytænoid muscles. The *superior border* is concave, and joined to that of the opposite cartilage (by means of the *ligamentum crico-arytænoideum*). The *inferior border* (*processus vocalis*) gives attachment, posteriorly, to the vocal cord. The *anterior border*, thick and convex, and covered by the mucous membrane, circumscribes, superiorly and laterally, the entrance to the larynx; it is in joining above, with the homologous border of the other arytænoid cartilage, that the pitcher-beak already mentioned is formed. The *posterior border* projects into the larynx by its inferior portion; superiorly, this border is very thick, and is hollowed by a small articular facet, which articulates with the anterior facet of the bezel of the cricoid. Above, and to the outside of this facet, is a very prominent tubercle (*processus muscularis*) that terminates behind the crest of the external face, and gives attachment to the posterior crico-arytænoid muscle.

Articulations of the Laryngeal Cartilages (Figs. 312, 313).—These are of the simplest kind. They are as follows:—

A. The thyroid cartilage is joined to the os hyoides: 1. At the extremities of the cornua, by means of a short ligament interposed between that extremity and the appendix of the superior border of the thyroid. 2. To the whole extent of the hyoid concavity, by an elastic membrane—the *thyro-hyoid membrane*, attached to the body of the thyroid cartilage and the superior border of the lateral plates of that cartilage (Fig. 313, 4).

B. The thyroid cartilage articulates with the cricoid by two small arthrodiæ, which unite the posterior extremities of the branches of the first cartilage to the facets on the external face of the second. A thin external capsule encloses this articulation (Fig. 312, 2). These two cartilages are also held together by means of a membranous elastic ligament—the *crico-thyroid membrane*, which passes from the angle comprised between the two branches of the thyroid to the anterior notch of the cricoid (Fig. 313, 3).

C. The two arytænoid cartilages are united, at their superior border, by the arytænoid muscle and laryngeal mucous membrane.

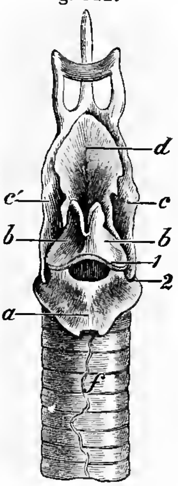
D. The latter cartilages come in contact with the anterior facets of the cricoid bezel, by means of the concave articular surface of their posterior border; the result is a small, but very movable, arthrodial joint, enclosed by a thin external capsule and by the surrounding muscles (Fig. 312, 1).

E. These cartilages are also united to the thyroid, through the medium of the *vocal cords*. These are two elastic bands which project within the larynx, and between them include the triangular space termed the *glottis*; their internal face is covered by the mucous membrane of the larynx; the thyro-hyoid muscles envelop their external face; their inferior extremity is fixed into the crico-thyroid membrane, and the angle of the thyroid cartilage; the superior is attached to the inferior border of the arytænoid cartilage, towards the angle which separates this from the posterior border. The articulation of sounds is principally due to the vibration of these cords (Fig. 313, D).

F. The epiglottis is attached by amphiarthrosis to the body of the thyroid cartilage, by means of elastic fasciculi mixed with fat, which pass from the base of the first to the upper face of the second. It is not rare to find among these fasciculi small synovial bursæ.

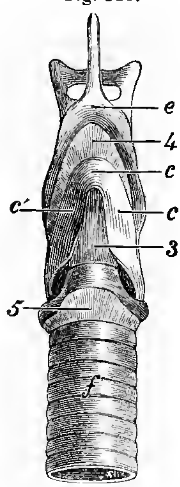
G. The epiglottis is united, laterally, to the inferior border of the arytænoids, through the medium of the two mucous folds already noticed, in the substance of which are the cartilaginous prolongations annexed to the base of this fibro-cartilage. These prolongations circumscribe, anteriorly, the ventricles of the

Fig. 312.



SUPERIOR FACE.

Fig. 313.



INFERIOR FACE.

CARTILAGES OF THE LARYNX, HELD IN THEIR NATURAL POSITION BY THE ARTICULAR LIGAMENTS.

a Cricoid cartilage; *b*, *b*, arytænoid cartilages; *c*, body of the thyroid; *c′*, *c′*, lateral plates of the thyroid; *d*, epiglottis; *e*, body of the hyoid bone; *f*, trachea. 1, Crico-arytænoid articulation; 2, capsule of the crico-thyroid articulation; 3, crico-thyroid membrane; 4, thyro-hyoid membrane; 5, crico-trachealis ligament.

larynx, and are sometimes designated the *superior vocal cords*—a name rarely given them, as they do not merit it.

H. Finally, the first ring of the trachea is attached to the cricoid cartilage by a circular elastic membrane.

All of these articulations have neither the same importance nor mobility. The kind of movements they permit is easily understood, and they are sufficiently indicated in the description of the muscles which execute them.

It is sufficient here to state, that these movements may either produce the shortening or elongation of the larynx, its dilatation or contraction in a transverse direction, or the occlusion of its anterior opening.

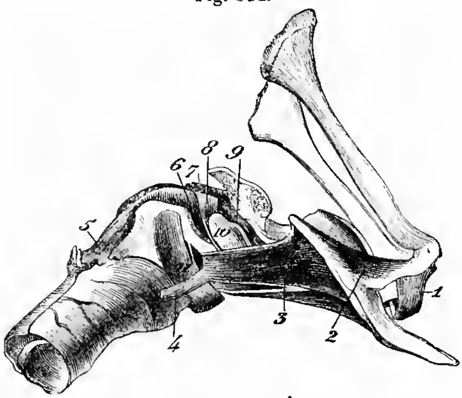
2. *Muscles of the larynx.*—The laryngeal apparatus is elevated or depressed with the hyoid bone, which it follows in all its movements. It is also moved

by proper muscles, which either produce its total displacement, or cause the several cartilages to play upon each other. Among these muscles there are three extrinsic—the *sterno-thyroideus*, *hyo-thyroideus*, and the *hyo-epiglottideus*. The others are intrinsic, or attached in their origin and termination to the different pieces of the larynx; they are—the *crico-thyroid*, *posterior crico-arytænoid*, *lateral crico-arytænoid*, *thyro-arytænoid*, and the *arytænoideus* muscles. All are pairs, except the last and the hyo-epiglottideus.

Sterno-thyroideus.—(See p. 255.)

Hyo-thyroideus (Fig. 314, 3).—This is a wide, triangular muscle, formed entirely of muscular fasciculi, which arise from the whole extent of the hyoid cornu, and terminate on the external face of the thyroid ala; the most inferior are longest. This muscle covers the thyroid cartilage and the thyro-hyoid membrane. It is covered by the maxillary gland.[1]

Fig. 314.



MUSCLES OF THE HORSE'S LARYNX.

1, Hyoideus transversus; 2, kerato-hyoideus; 3, hyo-thyroideus; 4, sterno-thyroideus; 5, crico-arytænoideus posticus; 6, crico-arytænoideus lateralis; 7, arytænoideus; 8, posterior fasciculus of the thyro-arytænoideus; 9, anterior fasciculus of ditto; 10, lateral ventricle of the larynx artificially distended and projecting between the two fasciculi; 11, crico-thyroideus

In contracting, this muscle brings the thyroid cartilage within the branches of the hyoid bone, and in this way carries the larynx forward and upward.

Hyo-epiglottideus.—This is a small cylindrical fasciculus, the fibres of which are buried in the middle of a mass of adipose tissue, and extend from the superior surface of the body of the hyoid bone to the antero-inferior face of the epiglottis. Partly covered by the mucous membrane of the pharynx, this muscle concurs in restoring the epiglottis to its normal position after the passage of food or water over it. But it is also necessary to state that the epiglottis is carried forward more particularly by its own proper elasticity, as well as that of the ligamentous bands that attach it to the thyroid cartilage.

Crico-thyroideus (Figs. 314, 11; 315, 8).—This small muscle, applied to the external side of the cricoid cartilage, is elongated from above to below, and composed of somewhat tendinous fibres which cross, more or less, the general direction of the muscle. They arise from the above-named cartilage, and pass to the posterior border of the thyroid plate.

The crico-thyroideus shortens the larynx, in bringing together the two cartilages into which it is inserted.

Posterior Crico-arytenoideus (Figs. 314, 315, 5).—This is the most powerful muscle in this region. Its fibres are directed forwards and outwards, and arise from the bezel of the cricoid, which they cover, and from the median crest of that part. They all converge, in becoming more or less tendinous, towards the posterior tubercle of the arytænoid cartilage, on which they terminate. Covered by the œsophagus and the crico-pharyngeal muscular band, this

([1] This and the preceding muscle are usually described as one—the *sterno thyro-hyoideus*.)

muscle is separated from that of the opposite side by the median crest of the cricoid bezel.

The posterior crico-arytænoid muscles dilate the entrance to the larynx, as well as the glottis, in causing the arytænoid cartilages to rotate or swing on the cricoid cartilage, and in separating them from one another by their anterior and inferior borders. They act as a lever of the first order.

Lateral Crico-arytænoideus (Figs. 314, 6; 315, 5). A triangular muscle, smaller than the preceding, situated between the thyroid and arytænoid cartilages, and formed of fasciculi longer in front than behind; these arise on the side of the anterior border of the cricoid cartilage, and are directed upwards, to terminate outside the posterior crico-arytænoideus, on the tubercle of the arytænoid cartilage.

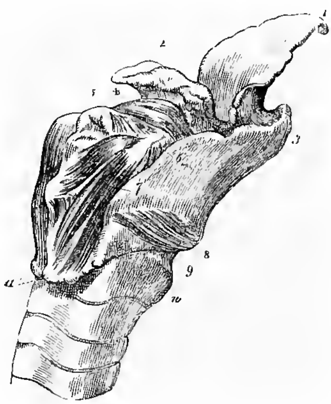
It is a direct antagonist of the last muscle, and, consequently, a constrictor of the larynx.

Thyro-arytænoideus (Figs. 314, 8, 9; 315, 6).—Lodged at the inner face of the thyroid ala, this muscle comprises two fasciculi, separated by the ventricle of the glottis.

The anterior fasciculus is a long and pale band, arising from the internal surface of the ala of the thyroid cartilage, near its receding angle, and ascending to the arytænoid cartilage, bending round its external face to join on the median line, the analogous fasciculus from the opposite side, mixing its fibres with those of the arytænoideus. By its inner face, it covers the superior vocal cord and the laryngeal mucous membrane.

The *posterior fasciculus*, wider than the anterior, comports itself in a somewhat similar manner. It commences from behind the same point, and terminates on the external crest (*processus muscularis*) of the arytænoid cartilage; but its most anterior fibres pass over this crest, and join the arytænoid muscle. Its internal face is in contact with the vocal cord, and its posterior border is confounded with the fibres of the lateral crico-arytænoideus.

Fig 315.



POSTERO-LATERAL VIEW OF THE LARYNX.

1, Epiglottis; 2, arytænoid cartilages; 3, thyroid cartilage; 4, arytænoideus muscle; 5, crico-arytænoideus lateralis; 6, thyro-arytænoideus; 7, crico-arytænoideus posticus; 8, crico-thyroideus; 9, ligament between the cricoid cartilage aud first ring of trachea, 10; 11, infero-posterior extremities of crico-thyroid cartilages.

Sometimes it happens that these fasciculi are not distinct from each other, and exist only as a wide muscular band applied against the ventricle of the glottis.

It is surmised that this muscle is a constrictor of the larynx. Its function is particularly marked in phonation, when it modifies the length, separation, and tension of the vocal cords.

Arytænoideus.—Situated beneath the pharyngeal mucous membrane, above the arytænoid cartilages, this, the smallest of the laryngeal muscles, is composed of two lateral portions, the fibres of which arise from a median raphé and, diverging, pass to the superior part of the external face of these cartilages, where they are inserted into the crest dividing that face, and unite with the thyro-arytænoid muscle.

The French works on Veterinary Anatomy cite this muscle—we do not know why—as a dilator of the larynx. Its position in front of the crico-arytænoid cartilages sufficiently indicates that it cannot act otherwise than in bringing the two arytænoid cartilages together. And the continuity of a large number of its fibres with those of the thyro-arytænoideus, does not allow it to have any other action than that of this muscle.

3. *Mucous membrane of the larynx.*—This membrane is only a continuation of that of the pharynx, which, after covering the prominence formed by the opening of the larynx, passes over the circumference of that opening, to be spread on the posterior face of the epiglottis and the internal face of the arytænoid cartilages, to dip into the ventricles, pass above the vocal cords, line the inner face of the cricoid cartilage, and, finally, to be prolonged into the trachea. Its deep face adheres closely to the parts it covers, except in the lateral ventricles. The free face is perfectly tense, and is covered with stratified tesselated epithelium at the epiglottis and vocal cords, but only with ciliated epithelium elsewhere.

The superficial layer of its dermis is composed of reticulated tissue except at the vocal cords, where it is closer and has some papillæ (Coyne).

The *glandulæ* of the larynx are racemose ; they are absent on the free border of the vocal cords, but are numerous on the posterior face of the epiglottis, where they are lodged in the minute depressions of the cartilage ; they are also found on the arytænoid cartilages and the arytæno-epiglottidean folds. There are closed follicles also in the vestibule of the larynx, at the limit of the arytæno-epiglottidean folds and the epiglottis, on the posterior surface of the latter.

The mucous membrane of the larynx possesses an exquisite sensibility, owing to which admission to the air-passage is denied to the solid or liquid alimentary particles, which, during deglutition, might deviate from their normal course and pass into this opening. The slightest touch brings into play this sensibility, and determines an energetic reflex action of the constrictor muscles of the larynx and chest ; from this results the almost complete occlusion of the larynx, and a violent cough which expels the substances that have caused the irritation of the membrane. Every one has experienced the effects of this reflex action, and knows by experience the great sensibility of the larynx.

4. *Vessels and nerves.*—Blood is carried into the larynx by the *laryngeal arteries*, which pass between the cricoid and the posterior border of the thyroid cartilages. Their branches spread over the ventricle of the glottis and the thyro-arytænoid muscle, to be expended in the substance of the muscles and mucous membrane. The terminal ramifications form red plexuses on the surface of certain parts of the larynx. The *veins* are satellites of the arteries. The *lymphatics* form a superficial and a submucous network.

The *pneumogastric* furnishes the larynx with its principal nerves—the *superior* and *inferior laryngeal*. The first is distributed to the upper part of the organ and the entrance to the glottis, endowing the mucous membrane with that high degree of sensibility which distinguishes it. The second is more especially a motor nerve, and supplies all the muscles, except the crico-thyroid. A filament of the recurrent nerve is distributed in the mucous membrane of the subglottal portion, and to the inferior border and inner surface of the vocal cords. The presence of nerve-filaments, analogous to those of the trachea, in the subglottal part of the larynx may explain the difference, well known to physiologists, that exists between the sensibility of the entrance to the glottis and that of the inferior border of the vocal cords.

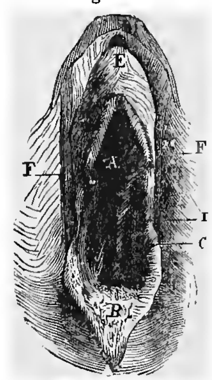
External Surface of the Larynx.—It is divided into four planes: a *superior*, *inferior*, and *two lateral*. The *superior plane*, formed by the arytænoid and posterior crico-arytænoid muscles, is covered by the pharynx and œsophagus; in its anterior moiety, it is directly covered by the pharyngeal mucous membrane.

The *inferior plane* presents, from before to behind, the thyro-hyoid membrane, the body of the thyroid cartilage, the crico-thyroid membrane, the inferior part of the cricoid cartilage, and the crico-trachealis ligament. There is remarked, laterally, the inferior border of the thyro-hyoid muscle. This plane corresponds to the scapulo-hyoideal muscles, which entirely cover it.

The *lateral planes* exhibit the external faces of the thyro-hyoid and crico-thyroid muscles, that of the cricoid cartilage, and the alæ of the thyroid. They also show the opening through which passes the superior laryngeal nerve; they are related to the crico- and thyro-pharyngeal muscles, as well as the maxillary gland.

Internal Surface of the Larynx (Fig. 316).—This surface (or *cavum laryngis*) is divided into three perfectly distinct regions: a middle, named the *glottis*; a superior, called the *supra-glottic portion*; and an inferior, designated the *infra-* or *sub-glottic portion*.

Fig. 316



ENTRANCE TO THE LARYNX OF THE HORSE.

A, Glottis; B, epiglottis; C, entrance to the lateral ventricle; D, vocal cord; E, œsophageal infundibulum opened; F, F, posterior pillars of the soft palate.

The *glottis* (*rima glottidis*) is a narrow space in the form of a very elongated isoscelated triangle, its base being uppermost. This irregular fissure is comprised between the elastic structures known as the vocal cords. It is the narrowest part of the larynx.

(The space between the vocal cords is designated the *glottis vocalis*, *pars vocalis*, or *interligamentous* portion; that between the arytænoid cartilages, the *glottis respiratoria*, *pars respiratoria*, or *intercartilaginous* portion.)

The *supra-glottic portion* (*aditus ad laryngem*, *introitus laryngis*), wider than the glottis, but always greatly depressed on each side, particularly in the region comprised between the arytænoids, presents: 1. The *two ventricles of the larynx* (*Morgagni's ventricles*), lateral excavations, dilated at the bottom, which penetrate between the anterior border of the vocal cords and the prolongations of the base of the epiglottis, insinuating themselves even between the fasciculi of the thyro-arytænoid muscle (in the Ass and Mule the ventricles are proportionately larger than in the Horse, and open close to the base of the epiglottis). 2. The *subepiglottic sinus*, a deep depression at the base of the epiglottis, which is provided, in the Ass and Mule, with a thin membrane, capable of vibrating. 3. The *entrance of the larynx*, or pharyngeal opening of the cavity, a vast, gaping aperture of an oval form, circumscribed by the anterior border of the arytænoids and the lateral border of the epiglottis, and making a remarkable projection at the bottom of the pharyngeal space.

The *subglottic portion* of the larynx is the widest of the three; it is directly continuous with the canal of the trachea. In front is seen the prominence formed by the posterior border of the vocal cords: above, a diffused and shallow excavation, placed at the point of junction of the arytænoid and cricoid cartilages, named the *subarytænoid sinus*.

Functions.—As a tube intended for the passage of a column of air during the act of respiration, the larynx does not give rise to any very interesting physiological considerations. It is, nevertheless, worthy of remark that this organ, like the nostrils, dilates or contracts, according to the volume of the column of air introduced into, or expelled from, the lungs, and that its paralysis, during rapid movements, causes an embarrassment in the respiration which betrays itself in "roaring." But a physiological study of the larynx acquires a real interest when it is examined with regard to the articulation of sounds, or as an organ of phonation. This study, however, does not come within our province; though what has been said concerning the vocal cords will give a summary, but satisfactory, idea of the mechanism which presides over this function, and the part the larynx plays.

It may also be added, that nearly all the muscles of the larynx are concerned in phonation, as by modifying the tension and the separation of the vocal cords, they determine differences in the sounds. One only is concerned in respiration; this is the posterior crico-arytænoideus, which is a dilator of the glottis.[1]

2. The Trachea (Figs. 317, 318).

Preparation.—Follow the same procedure as for the dissection of the œsophagus.

The *trachea* is a flexible and elastic tube, formed by a series of incomplete cartilaginous rings that succeed the larynx, and terminate above the base of the heart by two divisions, which constitute the *bronchi.*

Form.—This tube is cylindrical, and (slightly) flattened above and below. Its inferior face and two borders are regularly rounded, and offer transverse grooves, which correspond to the intervals between the constituent pieces of the trachea. The superior face, nearly plane, shows the thin and widened extremities of these cartilages.

Course.—Leaving the posterior extremity of the larynx, the trachea descends backwards to the entrance of the chest, in following the inferior border of the neck below the longus colli muscle. It afterwards becomes inflected, superiorly, to pass between the two first ribs, enters the chest, passes through the anterior mediastinum, proceeds directly backwards, and finally arrives above the left auricle of the heart, to the right of the posterior aorta, where it bifurcates.

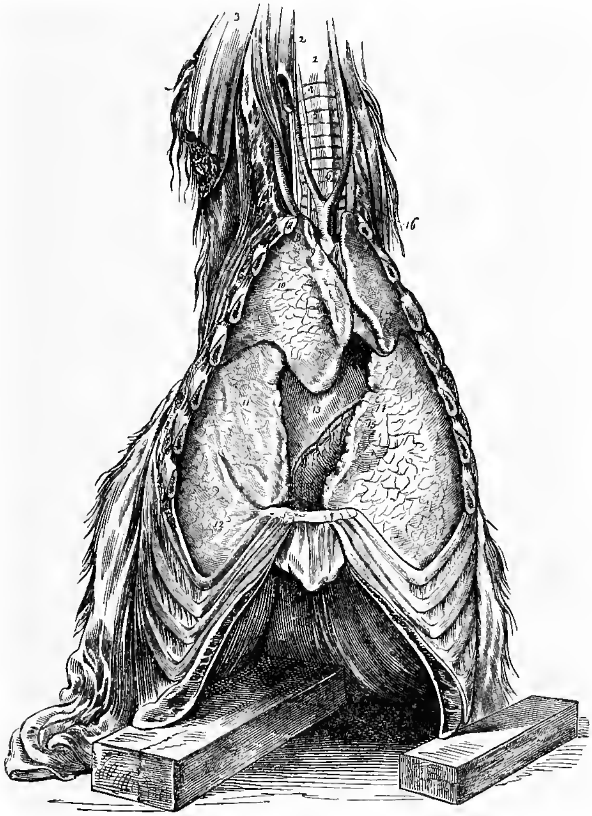
Relations.—*In its cervical portion,* the trachea, surrounded by a loose and abundant connective tissue, lies in a kind of muscular envelope which the majority of the muscles of this region form around it, and which are: the sterno-hyoid and sterno-thyroid, placed in front; the sterno-maxillaries, situated at first in front, and afterwards on the sides towards their termination; the subscapulo-hyoideii, above and in the middle of the lateral parts; the scalenii, altogether below and at the sides; the longus colli, behind; and outside all these muscles, the superficial expansion of the cervical panniculus. This envelope is thinnest in front of the middle portion of the neck; and this is the part where the operation of tracheotomy should be performed.

The trachea is also in relation, *in its cervical portion:* 1. With the œsophagus, which descends, as we know, at first in the middle of the posterior face, then to the left side of the air-tube. 2. With the carotid arteries, which pass along both sides of the tube, accompanied by their satellite nerves—the pneumogastric, great sympathetic, and recurrent nerves.

([1] For a special and detailed description of the anatomy and physiology of the Horse's larynx, consult my work on *Roaring in Horses* (*Laryngissimus paralyticus*). London: 1889.)

After clearing the two first ribs, where it reaches *its thoracic portion*, the trachea responds, superiorly, to the longus colli and the œsophagus; below to the brachial vessels, the anterior aorta which furnishes them, the anterior vena cava, the cardiac and recurrent nerves, and to the base of the heart; laterally, to the inferior cervical ganglia of the great sympathetic, the vertebral vessels—cervical and dorso-muscular—and to the two layers of the anterior mediastinum;

Fig. 317.



THE RESPIRATORY ORGANS (INFERIOR, OR FRONT VIEW).

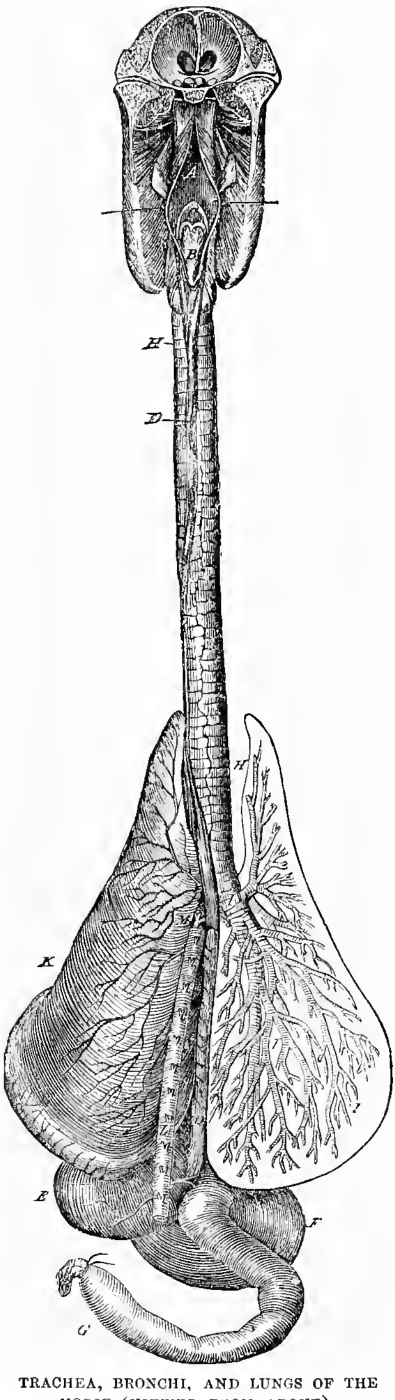
1, Trachea; 2, jugular vein; 3, rectus anticus major; 4, carotid artery; 5, longus colli; 6, origin of the common carotids; 7, vertebral artery; 8, section of first rib; 9, cephalic trunk of right axillary artery; 10, anterior lobe of right lung; 11, middle, or supplementary lobe of ditto; 12, posterior portion or lobe of ditto; 13, heart; 14, cardiac artery; 15, ventricular branch of cardiac vein; 16, œsophagus.

to the right, the vena azygos; to the left, the arch of the aorta and the thoracic duct. The latter is sometimes carried to the opposite side.

STRUCTURE.—The trachea comprises in its structure: the *cartilaginous rings* which form its base; the *ligaments* which unite these rings; the *mucous membrane* spread over its inner face; a *muscular layer*, which only lines that membrane superiorly; and *vessels* and *nerves*.

Cartilaginous rings of the trachea.—These are about fifty in number, and do

Fig. 318.



TRACHEA, BRONCHI, AND LUNGS OF THE HORSE (VIEWED FROM ABOVE).

A, Pharyngeal cavity, thrown open to show the entrance to the œsophagus, B, and that of the larynx, C; D, œsophagus; E, left sac of the stomach; F, its right sac; G, duodenum; H, trachea; I, right bronchial ramifications; K, left lung; L, anterior aorta; M, common origin of the bronchial, œsophageal, and first intercostal arteries.

not form perfect rings, being incomplete on the upper side of the trachea. Each is a kind of arc, composed of a cartilaginous plate flattened and curved on itself; the extremities are turned towards each other, and joined in the majority of the rings; they even overlap in some. These extremities are thin and wide, and sometimes bifurcate and unite with the adjoining rings.

In the middle part of the trachea, these rings are generally larger than at the origin or termination of the tube. The last ring, in serving as a transition between the trachea and bronchi, presents a more complicated arrangement, being frequently completed by isolated cartilaginous plates, and always divided by a median spur or bifurcation—directed towards the interior of the trachea—into two lateral segments, each of which corresponds to a bronchus.

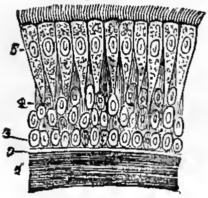
Ligaments.—The rings of the trachea are united at their borders by intermediate ligaments, which are composed of elastic tissue, and permit the lengthening or shortening of the tube they concur to form.

Towards the extremities of the arcs, they are confounded with a thin connective-tissue layer that unites these extremities. The first cartilage is received by its anterior border into the cricoid ring, and joined to it by the wide annular ligament mentioned at p. 531. Owing to the elasticity of this ligament, the two cartilages it binds together can move one within the other, like two segments of a telescope, and in this way vary the length of the tube.

Muscular layer.—This layer only covers the superior face of the trachea; it is formed of pale, rose-coloured, transverse fasciculi, attached by their extremities to the internal face of the cartilages. Its action undoubtedly diminishes the diameter of the trachea, by contracting the arcs composing this tube. (Kölliker has found some longitudinal fibres passing across the transverse ones at the posterior part of the trachea. Leyh describes longitudinal fibres in the anterior wall of the trachea, between the mucous membrane and the cartilaginous rings, and which, he states, diminish the length of the tube.)

Mucous membrane.—Continuous with that of the larynx, this membrane is prolonged, through the medium of the bronchi, and in becoming modified in character, into the air-cells. Its free or superficial surface is perforated by glandular orifices, and exhibits longitudinal ridges which are ineffacable by distension ; it is lined with ciliated epithelium. Its deep face is covered with yellow elastic tissue disposed in longitudinal fasciculi, and adheres intimately either to the face of the cartilage and their intermediate ligaments, or to the posterior muscular layer.

Fig. 319.



CILIATED EPITHELIUM FROM THE TRACHEA.

1, External layer of longitudinal elastic fibres; 2, homogeneous surface layer of the mucous membrane ; 3, round cells ; 4, oval and oblong cells; 5, ciliated cells.

An essential characteristic which distinguishes this membrane from that lining the larynx, is its slight sensibility.

(The tracheal glands, the orifices of which are so numerous in the mucous membrane, abound towards the posterior part of the tube ; they are small, ovoid bodies, lying between the muscular and fibrous coats. Other glands, less in size, are placed between the layers of fibrous tissue uniting the cartilages at the sides of the trachea. Their secretion is poured out upon the free surface of the mucous membrane, to lubricate and protect it.)

Vessels and nerves.—The *small arteries* emanating from the vessels in the vicinity of the trachea—as the carotid and the collateral branches of the brachial arteries—supply it with blood. Its *nerves* come from the recurrent ; they show small ganglia on their track.

Functions.—Except as a tube for the passage of the inspired and expired air, the trachea performs no other function.

3. The Bronchi (Figs. 318, 320, 327).

Preparation.—After removing the lung from the thoracic cavity, it is filled with water by fixing the trachea to a water-tap. The bronchi may then be dissected by tearing and triturating the pulmonary tissue.

Each of the two bronchi—the terminal branches of the trachea—resembles a tree embedded in the substance of the lung, and sending out a multitude of branches.

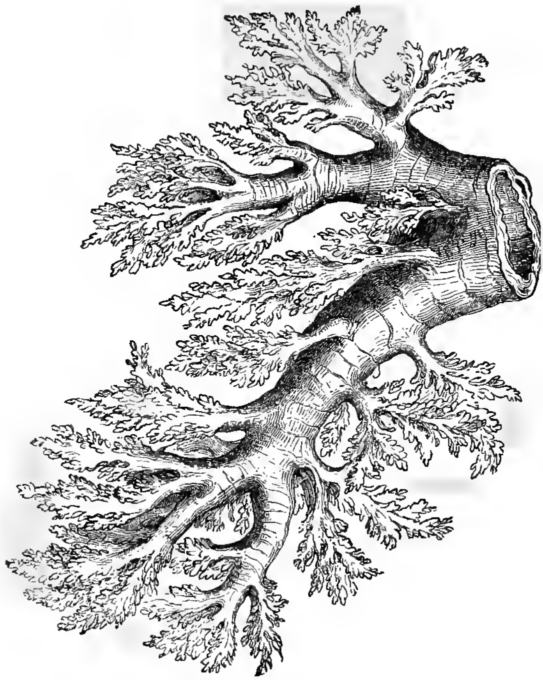
Arrangement.—At a short distance from their origin, the bronchi enter the lobes of the lung, and pass backwards and outwards towards the superior part of the base of the organ, giving off in their course large collateral branches, until they themselves are expended. These branches originate alternately above, within, below, and outwards ; and thus extend in every direction. The first forms an obtuse angle with the principal trunk, and is directed forwards, to ramify in the anterior lobe of the lung ; the others are detached at an angle more or less acute. All subdivide into gradually decreasing branches, which soon become of a capillary diameter, and finally open into the *infundibula* of the pulmonary air-cells (see Structure of the Lungs).

Form.—The bronchial tubes are not flattened like the trachea ; a transverse section shows them to be regularly cylindrical.

Volume.—The left bronchus is always smaller than the right, owing to the left lung being the least ; and both are much inferior in volume to the aggregate of their respective branches.

Relations.—Each bronchus enters the pulmonary lobe, or lung, along with the blood-vessels, with which it forms what is called the *root of the lung*. The divisions of this aborescent trunk are accompanied by the bronchial artery, vein, and nerves, which ramify in the same manner.

Fig. 320.



A SMALL BRONCHIAL TUBE, WITH ITS BRONCHULES AND ULTIMATE RAMIFICATIONS.

Near their origin, the bronchi are related to the bronchial glands, above which, and to the left side, passes the œsophagus.

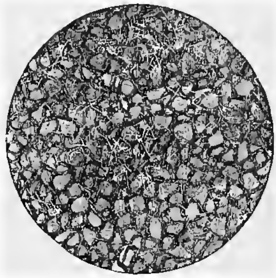
STRUCTURE.—The structure of the bronchial tubes resembles that of the trachea ; their walls being formed by *cartilages*, a *muscular layer*, *mucous membrane*, and *vessels* and *nerves*.

Cartilages of the bronchi.—These only exist in tubes of a certain calibre, the minute tubes being deprived of them, and having only membranous walls. As in the trachea, there is for each tube a series of transverse rings joined border to border ; though these are no longer formed of a single ring, but each results from the union of several lozenge-shaped pieces, the extremities of which overlap ; they are united to each other, like the segments of the neighbouring rings, by means of connective tissue, and also by the membranes spread over their internal surface.

Muscular layer.—Extended in a very thin continuous layer over the entire inner surface of the rings, this layer disappears in the smallest bronchial tubes.

Mucous membrane.—This membrane is distinguished from that of the trachea by its great sensitiveness; it alone constitutes the walls of the terminal bronchial divisions. (When the cartilages terminate, the tubes are wholly membranous, and the fibrous coat and longitudinal elastic fibres are continued into the ultimate ramifications of the bronchi. The muscular coat is disposed in the form of a continuous layer of annular fibres, and may be traced upon the smallest tubes; it is composed of the unstriped variety of muscular fibre.)

Fig. 321.



MUCOUS MEMBRANE OF A BRONCHIAL TUBE, WITH THE CAPILLARIES INJECTED.

Vessels and nerves.—The vessels and nerves distributed in the tissue of the bronchial tubes, come from the satellite vessels and nerves of these tubes—the *bronchial arteries*, *veins*, and *nerves*. The *lymphatics* pass to the bronchial glands.

Differential Characters in the Air-tube succeeding the Nasal Cavities in the other Animals.

Ruminants.—In the **Ox, Sheep,** and **Goat,** the interior of the *larynx* is simpler than in the Horse, and the lateral ventricles and vocal cords are almost effaced. The most important differences in its various pieces are as follows: 1. The thyroid cartilage has no anterior appendices, but is provided, posteriorly, with two considerable prolongations that articulate with the cricord cartilage (it has no excavation between the two wings, and is formed by a single piece: its inner face, in the middle, near the lower border, has a small fossette to which a round and very salient tuberosity on the external face corresponds). 2. The upper border of the cricoid is not notched in front (neither is the bezel on its lower border). 3. The epiglottis is wider, but not so pointed, than in Solipeds (Leyh says it is less extensive, but thicker). 4. A hypo-epiglottidean muscle bifid at its origin. (There is no arytæno-epiglottidean ligament.)

The *trachea* of these animals does not offer any important differences. The last ring is not so developed as in the Horse, and the tube detaches a supplementary bronchus to a lobe of the lung which does not exist in Solipeds. (The rings of the middle portion are proportionately narrow, and their extremities meet behind and form a salient ridge.)

In the **Camel,** the *larynx* is long and flattened before and behind, and the epiglottis is very developed; the entrance to the larynx is triangular in shape, but its borders are convex inwardly. In **Ruminants** there are some closed follicles at the base of the epiglottis.

Pig.—The *larynx* of the **Pig** is remarkable for its great mobility, suspended as it is to the hyoid cornua by the base of a very developed epiglottis, rather than by the wings of the thyroid cartilage. The epiglottis is in shape like an *omega*, is very high, and curved backwards in such a fashion as to envelop the arytænoids. There are wide, shallow, lateral ventricles, which have a small oblong sinus that ascends between the thyroid cartilage and the mucous membrane. These ventricles are not surrounded by the thyro-arytænoideus muscle, which is small and undivided; above and outwardly, they are margined by a thick cord—a kind of superior vocal cord, considered by Duges as acting with the ventricles to modify the deep grunting sounds. (Instead of a tuberosity on the external face of the thyroid cartilage, there is a median crest, and its inferior border has a small point. The cricoid appears to be drawn downwards and backwards, and its lower border is very prominent in the middle, and articulates with one or two small cartilaginous plates which have been sometimes wrongly described as belonging to the proper cartilages of the larynx. The antero-superior angles of the arytænoid cartilages are united to a small cartilaginous piece which prolongs them; their external face has a spine, and the internal angles are separated by a small pisiform body called the "interarticular cartilage.")

The *trachea* of this animal resembles that of Ruminants. (It has about thirty rings, and has three bronchi.)

Carnivora.—The larynx of the **Dog** and **Cat** is very like that of the Horse. In proportion, the epiglottis is shorter, wider at the base, and more triangular than in the other species; the lateral ventricles are shallow. (There is an interarticular cartilage, as in the Pig; there is no sub-epiglottidean ventricle, and the vocal cords appear to be nearer each other. The trachea has about forty-two rings, the extremities of which do not meet; the space between them is less in the Cat than the Dog.)

The larynx and trachea of *Man* will be compared with that of animals, when we come to describe the lungs.

The Thorax (Figs. 255, 322, 323, 324).

The *thorax*—also called the *thoracic* or *pectoral cavity*—lodges not only the lungs, but also the heart and the large vessels that arise from or pass to that organ, with a portion of the œsophagus and trachea; as well as nerves, which are as remarkable for their number as their physiological importance.

Situation.—We have seen that the thorax has for its base the bony cage formed by the ribs, sternum, and bodies of the dorsal vertebræ. Suspended beneath the middle portion of the spine, this cage is transformed into a closed cavity by the intercostal muscles, which fill the spaces between the ribs; and by the diaphragm, that vast oblique partition which separates the thorax from the abdomen.

Internal conformation.—Considered as a whole, the thoracic cavity represents a hollow cone placed horizontally, depressed on each side, and particularly in front towards the summit; with its base, formed by the diaphragm, cut very obliquely, in consequence of the direction taken by that muscle. This obliquity of the diaphragm renders the antero-posterior diameter of the cavity much greater above than below; the difference is more than double.

The internal surface of this conical cavity may be divided into six regions: a *superior*, *inferior*, and *two lateral planes*, a *base*, a *posterior plane*, and a *summit*.

The *superior plane* presents, on the middle line, a large projection resulting from the union of the vertebral bodies; and, laterally, two deep channels or furrows—the *vertebro-costal channels*. These latter, wider behind than before, are formed by the upper ends of the ribs; they lodge the superior border of the pulmonary lobes. The middle projection, or ridge, is comprised between these two lobes. Covered in front by the posterior extremity of the longus colli, this ridge is in relation with, for the remainder of its extent, the posterior aorta, the thoracic duct, and the vena azygos; on its sides are seen the subdorsal branches of the great sympathetic nerve.

The *inferior plane*, much shorter than the preceding, is, like it, narrower in front than behind; it has for base the superior face of the sternum, the sternal cartilages, and the triangularis sterni muscle. Posteriorly, it gives attachment to the fibrous sac containing the heart.

The *lateral planes*, more extensive than the other two, are concave in both their diameters. Formed by the internal face of the ribs and the deep intercostal muscles, they are in contact with the external face of the lung.

The *base*, or *posterior plane*, formed by the convex face of the diaphragm, is circumscribed on its exterior contour by the circle of asternal cartilages, and by the last rib. In it we see the three openings in the diaphragm.

The *summit*, or *entrance of the thorax*, is an oval opening, elongated vertically, comprised between the two first ribs and the longus colli muscle, and which is partly closed by an enormous collection of lymphatic glands; through this opening passes the trachea, œsophagus, axillary and carotid arteries, anterior vena cava, and the pneumogastric, great sympathetic, inferior laryngeal, and diaphragmatic nerves.

Such is the thoracic cavity. Like the abdomen, it is provided with a serous lining, which will now be examined.

THE PLEURÆ.—The serous lining of the thorax comprises two distinct membranes, named the *pleuræ*, forming two sacs placed one against the other in the median plane, and thus constituting a septum named the *mediastinum*, which divides the thoracic cavity into two lateral compartments. Each pleura, therefore, covers one of the external or costal walls of the thorax, and the corresponding moiety of the diaphragm ; it is afterwards reflected in the vertical and antero-posterior plane of the cavity, to concur in the formation of the mediastinum, whence it is carried over the lung. This arrangement exhibits the pleura in four portions—a *costal*, *diaphragmatic*, *mediastinal*, together representing the *parietal layer* of the membrane, and a *pulmonary* or *visceral* portion.

The *costal pleura* is applied to the inner face of the ribs and the internal intercostal muscles. Strengthened on its adherent face, at each intercostal space, by a layer of yellow elastic tissue, this membrane is related, by its free face, to the external surface of the lung, with which it does not, in a normal condition, contract any adhesions. It is continued posteriorly, by the diaphragmatic layer ; in front, above, and below, by the mediastinal pleura.

The *diaphragmatic pleura* adheres somewhat loosely to the fleshy portion of the muscle, but the union is more intimate on the aponeurotic portion. This layer is contiguous, by its free face, with the base of the lung ; it is confounded with the mediastinum by the internal part of its periphery.

The *mediastinal pleura* is placed, by its adherent face, against that of the opposite side, and in this way produce the middle septum that divides the thoracic cavity into two portions. Several organs are comprised between the two layers of this partition, but most important of all is the heart. In Veterinary Anatomy, that part of the septum in front of this organ is named the *anterior mediastinum* —the appellation of *posterior mediastinum* being reserved for the portion situated behind it. These terms have not the same signification as in human anatomy, though they are retained here to prevent misunderstanding.

The *anterior mediastinum*, thicker than the posterior, but much less extensive, contains, superiorly, the trachea, œsophagus, anterior aorta and its divisions, anterior vena cava, thoracic duct, and the cardiac, pneumogastric recurrent, and diaphragmatic nerves ; it also includes the thymus gland in the fœtus and very young animal. The *posterior mediastinum* is incomparably narrower below than above, in consequence of the oblique position of the diaphragm. Its inferior part, always deviated to the left, is extremely thin, and perforated by small openings, which give it the appearance of fine lacework. Traversed altogether superiorly by the posterior aorta, vena azygos, and thoracic duct, this mediastinum gives passage, a little lower between its layers, to the œsophagus, œsophageal branches of the pneumogastric nerves, and to the left diaphragmatic nerve. It is these layers of this mediastinum which pass to the lung to constitute the pulmonary pleura, in becoming reflected above and below, in a horizontal line extending from the root of the pulmonary lobe to the anterior face of the diaphragm.

The *pulmonary* or *visceral pleura*—a continuation, as has been said, of the mediastinal pleura—is in contact, by its free face, with the parietal layer of the membrane. Its deep face adheres intimately, in Solipeds, to the proper tissue of the lungs.

Independently of these four serous layers, the right pleura furnishes a special fold, which arises from the inferior wall of the thoracic cavity, and ascends to envelop the posterior vena cava. This fold also sustains the right diaphragmatic nerve.

In order to study the various portions of the pleuræ collectively, with their reciprocal relations, and their connections with the organs contained in the thoracic cavity, we will suppose three transverse sections of this cavity: one passing behind the heart; the other at the roots of the lungs, and dividing the left ventricle of the heart; the third traversing the anterior mediastinum, a little in front of the right ventricle.

If, in the first section (Fig. 322), we take the costal pleura at the point *a*, and follow it up to *b*, we shall see it folded downwards to form the mediastinal layer, to be applied to the aorta, *c*, and the œsophagus, *d*; then reflected at *e* on the lung, *f*, enveloping every part of the organ; returning to the point *e*, it

Fig. 322.

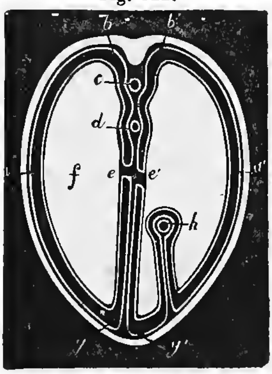


Fig. 323.

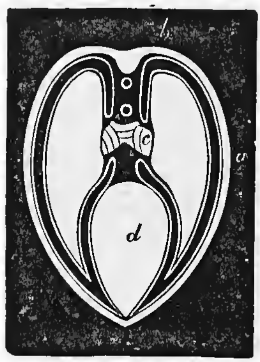
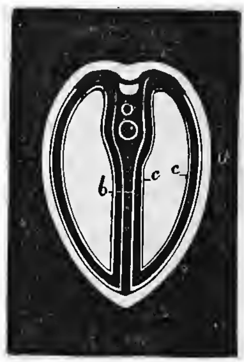


Fig. 324.



THEORETICAL SECTIONS OF THE THORACIC CAVITY, INTENDED TO SHOW THE DISPOSITION OF THE PLEURÆ.

leaves the lung, is again reflected to achieve the formation of the mediastinal septum, *b g*, and finally regains the point it started from. On the right side, with only a slight variation, it has the same arrangement. After being carried from the point *a'* to *b'*, then to *e'*, and after enveloping the lung, returning to *e'*, and being reflected in the median plane to the point *g'*, the right pleura leaves the inferior thoracic wall to pass around the posterior vena cava, and come back to *a'*, its point of departure.

The second section (represented by Fig. 323), shows the pleura arrived at the point *b*, descending on the root of the lung, *c*, covering that organ and returning to *c*; and reflected on the pericardium, *d*, to gain the point *a*.

In the third section (Fig. 324), we see the parietal pleura, *a b*, without any points of continuity with the visceral pleura, *c*. It is at the level of this section that the lung forms two perfectly free lobes, which are not attached to the anterior mediastinum.

Structure.—Like all the serous membranes, the pleuræ have a free face covered by a perfectly smooth endothelium, always in contact with itself, and constantly lubricated by a serous fluid which facilitates the gliding of the lung on the parietes of the thoracic cavity. The deep face is united to the subjacent parts by connective tissue destitute of fat; the adherence of the visceral pleuræ is most intimate.

The pleura has plexuses of *vessels*—one, the subserous, has large meshes; but a second, the endothelial, has a finer network.

The *nerves* are from the sympathetic and pneumogastric for the pulmonary pleura; from the diaphragmatic and intercostal nerves for the parietal pleura.

FUNCTIONS.—The thorax is not a mere receptacle, but, on the contrary, performs a very important part in the act of respiration. We know, in fact, that it is dilated and contracted by the movements of the diaphragm and the ribs (see pp. 193, 310). The lungs, being applied immediately against the thoracic walls, and never at any time separate from them, follow this cavity in their movements—dilating in inspiration and contracting in expiration, after a certain quantity of the oxygen of the inspired air has been removed and replaced by an equivalent amount of carbonic acid.

The movements of the thorax are, therefore, of capital importance, constituting, as they do, the initial phenomenon of respiration, and having dependent on them all the other acts of this function.

DIFFERENTIAL CHARACTERS IN THE THORAX OF THE OTHER ANIMALS.

In the **Ox**, the thorax is not so long, particularly in its superior part, as in Solipeds, by reason of the slight obliquity of the diaphragm, and of its mode of attachment to the ribs.

The total capacity of this cavity is also certainly inferior to that of the Horse's chest. It is the same, though relatively more extensive, in the **Sheep, Goat,** and **Pig**; while the **Dog** possesses in this respect an incontestable superiority over Solipeds. It is to be noted that all these animals, without exception, are distinguished from the Horse, Ass, and Mule by the conformation of the posterior mediastinum. In them it is not open in its lower part, but as solid, thick, and complete there as elsewhere. Therefore it is that the consecutive effusion of pleuritis is readily localized in one of the pleural sacs in the first-named animals, while this localization is impossible in the second. (This is an important observation, from a pathological point of view; but it is to be noted that exceptional instances have been recorded, in which the posterior mediastinum of the horse has been found imperforate.

The Lung (or Lungs) (Figs. 318, 321, 325, 326).

Preparation.—The disposition of the lung in the thoracic cavity is best studied by placing the subject in the second position, opening the chest by excision of the ribs, as in Fig. 322, and inflating the organ by the trachea. To study its external conformation, it should be removed from the cavity, with the heart and large vessels, and inflated as before.

Situation—General disposition.—This essential organ of respiration is a spongy viscus, lodged in the thoracic cavity, and divided into two lateral, but independent, moieties, each of which occupies one of the two serous sacs formed by the pluræ. It is also described as *two pulmonary lobes*, or *two lungs*—a *right* and *left*, the latter a little less voluminous than the former.

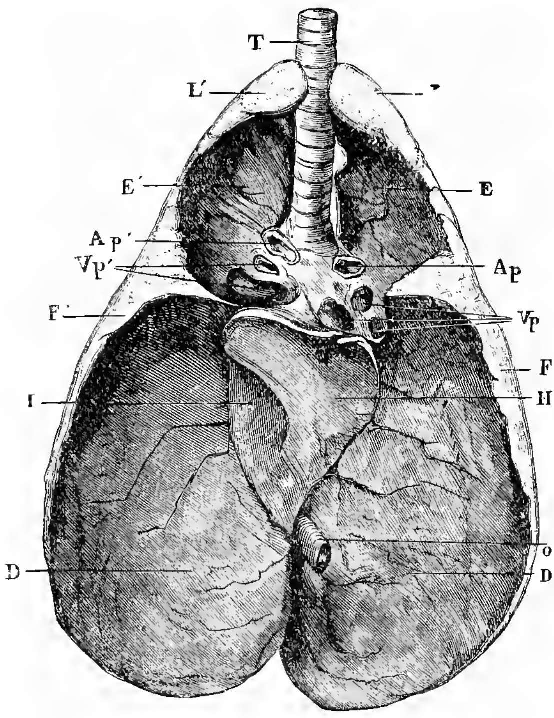
Form and Relations.—Together, the lungs affect the outline of the thoracic cavity; each represents the moiety of a cone,[1] and offers for study: an *external* and *internal face*, a *base* and *summit*, and a *superior*, *inferior*, and *posterior border*.

[1] This is not the natural shape of the lungs and is only assumed when the chest is opened, and their elasticity is no longer counterbalanced by the atmospheric pressure, except at the external surface of the bronchi.

The *external* or *costal* face is convex (and smooth), and moulded to the external wall of the thorax.

The *internal*, or *mediastinal face*, forms a vertical plane, separated from the opposite lung by the mediastinum. It shows : 1. A small anterior portion in contact with the anterior mediastinum. 2. At the heart, an excavation in which that organ is lodged. 3. Immediately behind this excavation, and a little above it, the *root of the lung* (*hilum-pulmonis*)—a fasciculus formed by the air-tubes and pulmonary vessels in entering the viscus. 4. A posterior portion, more extensive than the other two put together corresponding to the posterior mediastinum,

Fig. 325.



LUNG OF THE HORSE, SUSPENDED BY THE TRACHEA (VIEWED BY ITS BASE AND INFERIOR BORDER).

T, Trachea; L, L′, anterior lobes; E, E′, cavity for the heart; Ap, Ap, branches of the pulmonary artery at their entrance to the heart; Vp, Vp, pulmonary veins at their emergence from the lung; F, F, external face of the lobes of the lung; D, D, base of the lung, or diaphragmatic face of the two lobes; H, internal lobule of the right lobe; I, channel for the posterior vena cava; O, œsophagus passing between the two lobes (a certain retraction of the organ appears to make it pass between the lobe and lobule of the right lung).

and attached to that septum by means of a fold developed around the organ, to form the pulmonary pleura; this fold constitutes, posteriorly, a small serous ligament (*ligamentum latum pulmonis*), attached at once to the mediastinum and the posterior face of the diaphragm. On this portion of the lung are remarked two antero-posterior furrows : one, near the upper border of the organ, to receive the thoracic aorta ; the other situated lower, but not so deep, more marked in the left than the right, and lodging the œsophagus. In the right lung, this mediastinal face offers a small particular lobule, which is absent in the left.

The *base*, or *diaphragmatic face* of the lung, cut obliquely downwards and backwards, is concave, and moulded to the anterior face of the diaphragm. On the right lung is seen the posterior face of the small lobule noticed on the inner side, and a deep fissure between it and the principal lobe, for the passage of the posterior vena cava.

The *summit* of the viscus, situated behind the first rib, presents a kind of detached appendix—the *anterior lobule* of the lung.

The *superior border*, thick, convex, and rounded, is lodged in the vertebro-costal channel or concavity. The *inferior*, much shorter and thinner, is deeply notched at the level of the heart, and more so on the left than the right side. The *posterior* is elliptical, and everywhere circumscribed by the face of the diaphragm, which it separates from the costal and mediastinal faces.

STRUCTURE.—An *external serous envelope*, *proper fundamental tissue*, *functional* and *nutrient vessels*, *lymphatics*, and *nerves:* such are the elements which enter into the organization of the lung.

Serous Envelope.—This is the pleura pulmonalis already described. Lymphatic stomata are observed on its surface. (There has also been described a *subserous connective tissue*, containing a large proportiou of elastic fibres; it invests the entire surface of the lung, and extends between the lobules.)

Fundamental Tissue. *Physical characters.*—The pulmonary tissue in the adult is of a bright rose-colour; it has a deeper hue in the fœtus which has not respired. Although soft, it is yet very strong and resisting, and can with difficulty be torn. Its elasticity is remarkable, and is the cause of the collapse the lung experiences when air is admitted to the pleural sacs. It is very light—plunged in water, if healthy, it floats; this specific lightness is due to the air imprisoned in the pulmonary *infundibula*. This may be proved by what takes place when the lung of a fœtus is inflated: heavier than water before, it then becomes lighter, because, notwithstanding all the manipulatiou that may be employed to expel the air introduced into the pulmonary vesicles, a certain quantity always remains. On the other hand, the absolute weight of the lung is relatively more considerable in the adult than in the fœtus, the first representing $\frac{1}{30}$ of the total mass of the body, while it is only $\frac{1}{60}$ in the secoud.

A knowledge of these facts may be utilized in determining whether a given lung has belonged to an animal which has respired, or has died before birth. If the tissue is plunged in water, this test is called hydrostatic pulmonary docimacy; if its relative weight is to be ascertained, it is designated pulmonary docimacy by weight.

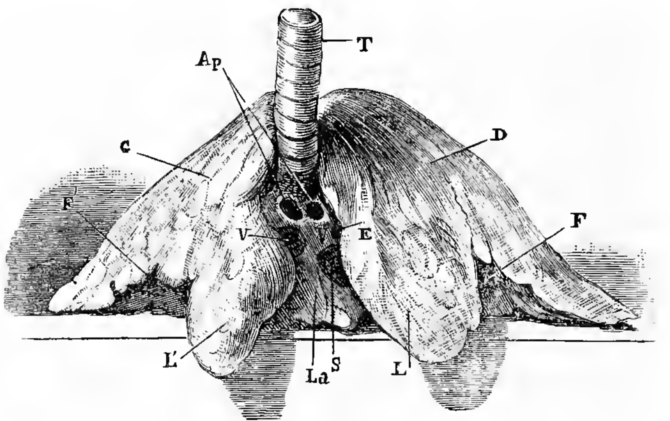
These are the physical characters of the fundamental tissue of the lung; we will now study its anatomical characters.

Anatomical characters.—The pulmonary tissue is divided into a great number of small polyhedral lobules by septa of connective tissue, which appear to be prolongations of the *corium* of the enveloping serous membrane. This segmentation into lobules is a common feature in the organization of the lungs in the Mammalia, but it is more readily demonstrated in some than others: not very evident in SOLIPEDS, and less so in the CARNIVORA, it is well defined in RUMINANTS and PACHYDERMS.

As the lobule constitutes the genetic unit of the lung, we will study its organization in detail, as has been already doue with regard to the hepatic lobule. It forms a small pyramid with a polygonal base, measuring about $\frac{1}{3}$ of a cubic inch, and is surrounded by a layer of connective tissue which unites it to the neighbouring lobules, and in which are some lymphatics and the network formed by the pulmonary vein. It appears to be suspended by its summit to a very short pedicle consisting of: 1. A sublobular bronchiole of about 0·039 inch in diameter. 2. A twig of the bronchial artery. 3. A branch of the pulmonary artery. 4. A division of the pulmonary vein. While the first three elements of the pedicle enter the lobule, the fourth deviates suddenly and becomes a capillary network on its outer surface.

In the lobule, the sublobular bronchule is named the *intra-lobular bronchiole;* it gives off the *lateral intra-lobular bronchioles* in passing towards the base of the lobule, where it throws off at last two *terminal bronchioles.* Each lateral bronchiole comports itself like the intra-lobular one, and terminates in the same

Fig. 326.



LUNG OF THE HORSE RESTING ON ITS DIAPHRAGMATIC SURFACE, AND VIEWED BY ITS ANTERIOR EXTREMITY.

T, Trachea; D, right lobe; G, left lobe; L, anterior lobule of the right lobe; L′, anterior lobule of the left lobe; Ap, branches of the pulmonary artery at their entrance into the two lobes; F, F′, notch on the right and left of the inferior border of the lung, in face of the heart; E, notch on the upper border for the passage of the aorta; V, V, openings of the pulmonary veins; La, lobule of the right lung; S, fissure for the passage of the posterior vena cava.

manner—by two *short* or *acinous bronchioles*, about $\frac{3}{10}$ of a millimetre in diameter.

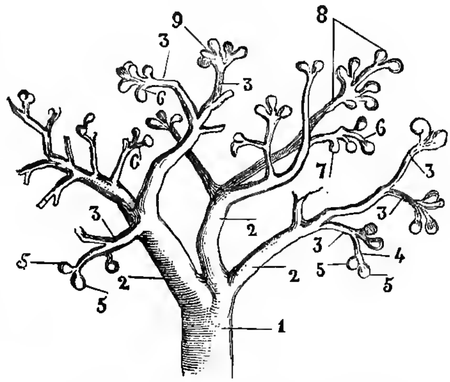
At the extremity of each of the terminal bronchioles—short or acinous—is suspended a small pyramidal mass of 2 to 3 cubic millimetres—the *acinus*, which at first showing an initial dilatation—the *vestibule*, afterwards gives off three, four, or five divergent tubes of from $\frac{1}{5}$ to $\frac{2}{5}$ of a millimetre—the *alveolar passages*, or, better, *respiratory canaliculi.* These are sacculated on their surface and expanded at their termination, so as to resemble small bunches of grapes in which the fruit is not very distinct from the stalk. The terminal dilatations are named *infundibula*, and the boss-like portions *alveoli*, or *pulmonary vesicles.*

The ramifications of the bronchial artery are expended in the tissue of the bronchioles, and do not extend beyond the commencement of the alveoli and infundibula; while the branches of the pulmonary artery accompany the bronchi, and become capillaries in the walls of the alveoli and infundibula. In this way the conductive and the respiratory parts, properly speaking, of the lung have an organic independence, just as they have a physiological and pathological individuality.

The elements of the pedicle, in ramifying in the lobule, carry with them a certain amount of connective tissue.

To demonstrate the structure of the lung, it may be inflated and dried, and sections afterwards made to show the pulmonary alveoli. But this procedure has the inconvenience of unduly distending these small cavities by thinning, and even destroying, their walls. A better method is the following: leave the lung in the intact thoracic cavity; by the jugular vein, pour into the right side of the heart an injection of very hot tallow, employing a certain amount of force to propel it from the pulmonary artery into the veins; when this injection has cooled, open the thoracic cavity, and take out the lungs These, being impregnated with solidified fat, do not collapse on contact with the air, and sections made in different directions then exhibit innumerable perfectly circular porosities, which are the open pulmonary vesicles.

Fig. 327.



CAST OF A PRETERMINAL AND TERMINAL BRONCHIOLE, FROM THE LUNG OF THE ASS.

1, Bronchiole of $1\frac{1}{2}$ millimetre in diameter; 2, 2, ramifications $\frac{1}{2}$ a millimetre in diameter; 3, 3, 3, 3, sublobular bronchioles; 4, ramifications of an intra-lobular bronchiole; 5, 5, infundibula; 6, 6, 6, respiratory canaliculi; 7, pulmonary alveoli; 8, *débris* from the canaliculated part of a pulmonary lobule; 9, acinus. A point has been chosen where the moulding of a great number of alveoli and acini failed, in order to show the divisions of the bronchi better. Magnified 5 diameters.

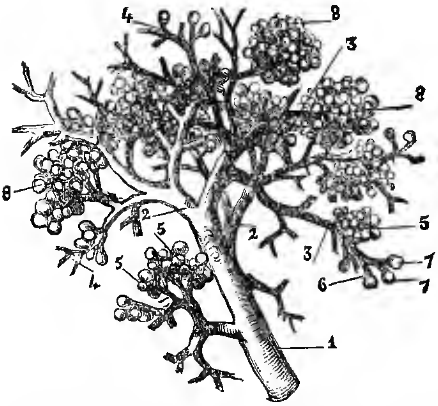
In this way it is easy to demonstrate the presence of the air-cells; but, in order to conveniently study their arrangement, it is necessary to take a cast of them by means of a solidifiable material introduced by the bronchi, and afterwards destroyed by the maceration of the pulmonary tissue. The Darcet alloy, employed in this manner, often gives very good results, as seen in figures 327, 328.

We will follow the preceding details on the interior of the lung, with some words on the structure of its different parts.

The *bronchiole*, on entering the lobule, has all the elements of the larger bronchi—cartilaginous rings, a layer of racemose mucous glands, muscular layer, festooned mucous membrane, and ciliated epithelium; but as it divides and becomes smaller, its composition is modified. The intra-lobular bronchioles successively lose their cartilages, the glandular layer, and the contractile layer, and at last at the acini the mucous layer is reduced to its *basement* membrane, and the epithelium becomes cubical. The walls of the infundibula are formed by a thin amorphous membrane strengthened externally by some connective tissue and an elastic network; while the interior is lined by a row of flat cells, the outline and nuclei of which can easily be made out in the adult animal. The capillaries form an extremely rich network spread outside the proper membrane—though sometimes they enter its substance, and push the epithelium towards the centre of the alveolus.

(The minute polygonal cells lining the air or pulmonary vesicles measure from $\frac{1}{1600}$ to $\frac{1}{2250}$ of an inch in diameter, and from $\frac{1}{2800}$ to $\frac{1}{3800}$ of an inch in thickness. Between the vesicles is a trabecular tissue, mainly composed of yellow elastic with a few muscular fibres, some of which are united with the lining membrane to strengthen it, especially around the apertures of communication between the adjoining air-cells.

Fig. 328.



CAST OF A PORTION OF THE BRONCHIAL DIVISIONS AND SOME LOBULES AND ACINI, FROM THE LUNG OF THE ASS.

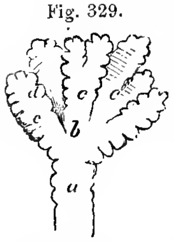
1, Bronchiole, 1½ millimetre in diameter; 2, 2, 2, ramifications of 1 millimetre; 3, 3, 3, 3, sub-lobular bronchioles; 4, 4, 4, intra-lobular bronchial divisions; 5, 5, acini; 6, 6, respiratory canaliculi; 7, 7, infundibula; 8, 8, 8, mould of complete lobules. It was necessary to break away a number of lobules in order to show these. Magnified 5 diameters.

The capillary plexuses are so arranged between the two layers forming the walls of two adjacent cells, as to expose one of their surfaces to each, in order to secure the influence of the air upon them. These networks are so close, that the diameter of the meshes is scarcely so great as that of the capillaries which enclose them.)

Vessels.—The lung is a very vascular organ. The numerous ramifications it receives divide into two orders—the functional and the nutritive vessels.

Functional vessels of the lung.—The blood is returned from all parts of the body by the veins, after losing, along with its bright red colour, the properties which render it fit to maintain the vitality of the tissues. It thus arrives at the *right* side of the heart, whence it is propelled into the lung, there to be regenerated by mediate contact with the air. It is the *pulmonary artery* which conveys this fluid into the parenchyma of the organ, and by the *pulmonary veins* it is carried back to the heart. The artery is at first divided into two branches, which ramify, and finally terminate in dense capillary plexuses upon the walls of the infundibula. The veins—innumerable and attenuated at their origin, like the arterial capillaries—terminate in from four to eight principal trunks, which open into the left auricle of the heart.

Fig. 329.



PLAN OF A PULMONARY LOBULE.

a, Bronchiole terminating in a slight dilatation, *b*; *c*, air-sacs, or infundibuli; *d*, air or pulmonary vesicles.

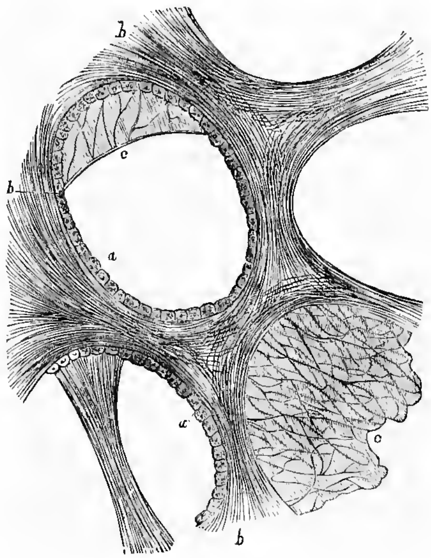
The branch of the pulmonary artery that enters each lobule, is regarded as terminal—that is, it does not anastomose directly with the arteries of the neighbouring lobules; on the contrary, the interlobular branches of the pulmonary vein are in relation with the capillary network of the adjoining lobules.

These two orders of vessels, which necessarily participate in the physiological functions of the lung—like the vena portæ with the liver—are very justly distinguished from the other arteries or veins, by the designation of *functional vessels*. But though they are so named, it must not be inferred that they are excluded from all participation in the acts of nutrition.

Nutrient vessels.—By this name is designated the divisions of the *bronchial arteries* and *veins*, the terminal ramifications of which anastomose with the capillaries of the pulmonary vessels at the ultimate bronchules.

It is generally admitted that the two arterial systems—bronchial and pulmonary—are independent of each other, and also of the general circulation. Küttner believes he has in several ways demonstrated the existence of communications between bronchial and pulmonary arterioles, and between the latter and the subpleural arterioles.

Fig. 330.



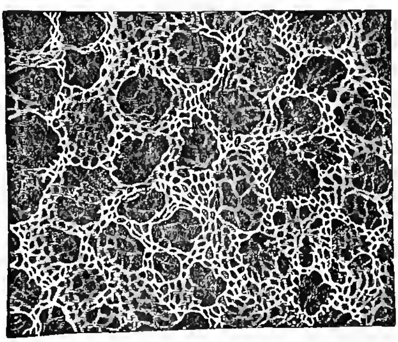
INFUNDIBULA OF LUNG, WITH INTERVENING TISSUES.

a, Epithelium; *b*, elastic trabeculæ; *c*, membranous wall, with fine elastic fibres.

Lymphatics.—These vessels are divided into *superficial* and *deep*. The first form a network beneath the pleura; the second exist in large numbers around the lobules. They mix and terminate in the bronchial glands; but before doing so, they enter the small lymphatic masses disseminated in the texture of the lung, in the neighbourhood of the bronchi. There are also interlobular lymphatics which follow the ramifications of the bronchi and pulmonary artery. (Lymphatics of very small size have been described as commencing in the alveolar spaces, on leaving which they gain a proper coat or internal tunic, and are subsequently supplied with valves.)

Nerves.—The nerves supplied to the tissue of the lung come from the same source as those of the bronchial tubes—the *pneumogastric* and *great sympathetic nerves*. Their ramifications accompany the pulmonary vessels and bronchi, and they show small ganglia on their course.

Fig. 331.



ARRANGEMENT OF THE CAPILLARIES AROUND THE INFUNDIBULA.

Functions.—To know that the lung is the seat of the absorption of oxygen and the expulsion of carbonic acid from the nutritive fluid—phenomena accompanied by the transformation of the dark into red-coloured blood, and the cooling of the venous blood—is the only authentic fact necessary to remember with regard to the functions of this organ. It must be added that the operations from which all these phenomena result, take place in the lung by the mediate contact of the atmosphere introduced into the pulmonary alveoli during inspiration, with the blood traversing the walls of these spaces. With the intimate mechanism of these actions we have nothing to do here, however.

Development.—Although the lung is in a state of inactivity in the fœtus, yet it is one of the early developed organs. During the whole period of fœtal existence, its lobular texture is much better defined than in the adult, and it then appears to be formed exactly like a racemose gland. Sections of it prepared for microscopical examination, distinctly show the vesicles and their arrangement. We have already made known the differences in colour and density which distinguish the pulmonary tissue of the fœtus and that of the adult. It only remains to repeat what has been said as to the slight vascularity of the first, and to note that the blood of the pulmonary artery passes almost entirely into the posterior aorta by the arterial canal (or *ductus arteriosus*).

Differential Characters in the Lungs of the other Animals.

The form of the lungs of **Ruminants** does not differ from that of the Horse, except that the left is divided into two lobes, and the right into four—the anterior of these being curved in front of the heart. This is shown in Fig. 332.

The lungs of the **Ox, Sheep,** and **Goat** are remarkable for the distinctness with which the lobules are defined. They are, in fact, separated by loose connective tissue, which, by a certain degree of traction, may extend 1 or 2 millimetres; it forms a reticular and alveolar system capable of being developed by insufflation. Renant and Pierret have shown that the dilatable tracts are lymph spaces, lined with a characteristically festooned epithelium; so that the pulmonary lobules in the lung of the Ox are bathed in a lymphatic sac.

As a consequence of inflammation, these spaces, are gorged with fibrine and leucocytes, and contrast strikingly, by their pale tint, with the lobules; therefore the lesions of pneumonia in the larger Ruminants have an altogether special character—a fact to which Dietrichs drew attention a long time ago.

In the **Pig**, the lungs comport themselves somewhat like those of Ruminants.

In the **Dog** and **Cat**, there is no well-marked fissure in either lung towards the heart, which causes that organ to be almost completely enveloped by pulmonary tissue. The left lung has three lobes, and the right four, separated from one another by deep furrows, which are generally prolonged to the root. The lobules are small, very close, and the pulmonary tissue is exceedingly compact. (The pulmonary infundibula are proportionately larger than in Ruminants)

Comparison of the Larynx, Trachea, and Lungs of Man with those of Animals.

1. *Larynx.*—The human larynx is proportionately shorter and wider than that of animals. The principal *cartilages* are those which have been already studied; but there are, besides, small cartilaginous bodies, to which special names have been given: these are the cartilages of Santorini and of Wrisberg. The facets on the cricoid for articulation with the thyroid are placed on the small cornu detached from the external face of the cartilage. The thyroid is wide, and protects the anterior face of the larynx; the angle formed by the alæ, which is more marked in the male than the female, is very prominent, and is named the pomum Adami. The epiglottis is short, broad in its middle, and rounded at its summit, something like that of the Carnivora. The muscles are the same in number and disposition as in these animals; but there is distinguished an oblique arytænoideus—a fasciculus of the arytænoid, which crosses its fellow to form an X in passing from the upper border of one arytænoid cartilage to the lower border of the other.

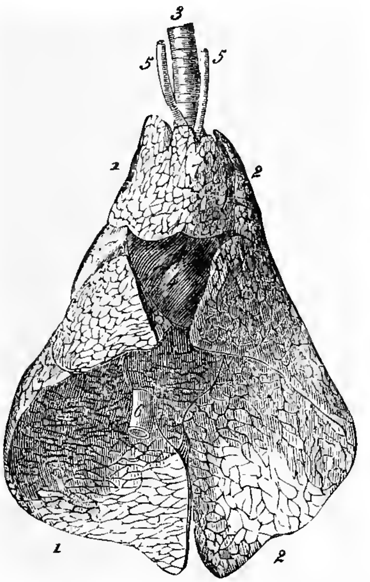
Internally, the human larynx has no sub-epiglottic or sub-arytænoid sinus like that of Solipeds, though it has lateral, or Morgagni's, ventricles that ascend a little to the outside of the superior vocal cords.

2. *Trachea.* 3. *Bronchi.*—There is little difference to be remarked in these. The trachea is about four inches long and about one inch wide, and is composed of about twenty C-shaped rings, which are closely united as in animals. It is situated in the median plane, in the upper part of the neck, where it is embraced by the lobes of the thyroid gland; at its entrance into the chest it deviates slightly to the right. The two short canals between its lower extremity

and the lungs are the *bronchi;* the right bronchus is the shortest and widest, and has an almost horizontal direction, entering the right lung at the fourth dorsal vertebra; the left is longer and less voluminous, and reaches the corresponding lung at the fifth vertebra.

4. *Lungs.*—The lungs weigh about forty ounces. As in all animals, the right is more voluminous than the left, and is divided into three lobes; the latter has only two. The inferior vena cava is not surrounded by pulmonary tissue; the principal lobes are partitioned into lobules, which are visible on the surface, and on the limits of which are deposited, only in

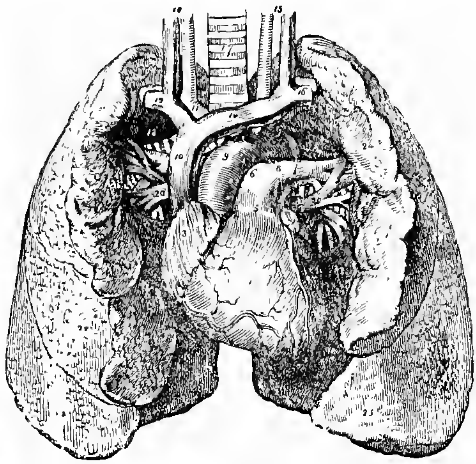
Fig. 332.



LUNG OF THE SHEEP (INFERIOR VIEW).

1, Right lung; 2, left lung; 3, trachea; 4, heart; 5, carotid arteries; 6, posterior vena cava.

Fig. 333.



HUMAN LUNGS AND HEART (FRONT VIEW).

1, Right ventricle; 2, left ventricle; 3, right auricle; 4, left auricle; 5, pulmonary artery; 6, right pulmonary artery; 7, left pulmonary artery; 8, ligament of ductus arteriosus; 9, arch of aorta; 10, superior vena cava; 11, arteria innominata; 12, right subclavian vein, with the artery behind it; 13, right common carotid artery and vein; 14, left vena innominata; 15, left carotid artery and vein; 16, left subclavian vein and artery; 17, trachea; 18, right bronchus; 19, left bronchus; 20, 20, pulmonary veins; 21, superior lobe of right lung; 22, middle lobe; 23, inferior lobe; 24, superior lobe of left lung; 25, inferior lobe.

the adult, a notable quantity of pigmentary matter, that gives the lungs the appearance of a chess-board. There is nothing to be said respecting their internal conformation and structure.

The Glandiform Bodies connected with the Respiratory Apparatus.

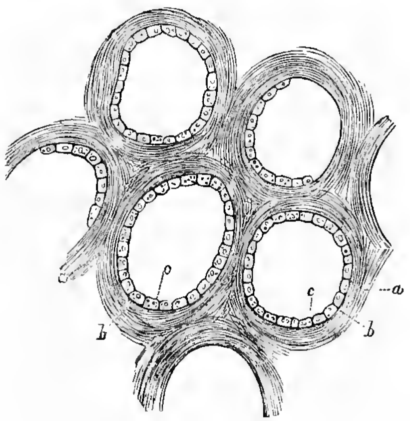
1. Thyroid Body, or Gland (Fig. 334).

The *thyroid body* consists of two oval lobes of a reddish-brown colour, and is situated close to, and behind, the larynx, beside the two first rings of the trachea.

These two lobes, distinguished as right and left, appear at first sight to be perfectly independent; but close examination shows them to be united by an intermediate portion (the *isthmus*), which passes across the anterior face of the trachea. This connecting portion is far from being constant in the **Horse,** while it is nearly always present in the **Ass.**

Each lobe of the thyroid body is related, inwardly, to the trachea ; outwardly, it is covered by the subscapulo-hyoideus muscle.

Fig. 334.



GROUP OF GLAND VESICLES FROM THE THYROID BODY OF A YOUNG SUBJECT.

a, Connective tissue ; *b*, basement membrane of the vesicles ; *c*, epithelial cells.

STRUCTURE.—The thyroid body is composed of a fibrous envelope, and a proper tissue or parenchyma.

The *fibrous envelope* is composed of slender, but strong connective tissue ; it sends from its inner face a large number of thin nucleated layers that intersect each other, forming spaces in which the proper tissue is contained.

The *parenchyma* is divided into lobules, the presence of which is manifested on the surface of the organ. They are composed of vesicles communicating with each other, the shape and contents of which vary considerably with age and situation. In the fœtus, or very young animal, they are round or elliptical, and constituted by a thin amorphous membrane, lined by polygonal cells with a large nucleus, and containing a granular fluid. In the adult, these vesicles are misshapen, and, after being distended, several run together, while the epithelium is less evident, but uniform ; the contents have become brown, and hold granules and nuclei in suspension ; and, finally, they often assume the character of colloid matter, in becoming viscid and of a yellow tint.

Vessels and nerves.—The thyroid body is remarkable for the relatively enormous volume of its blood-vessels ; the *arteries* chiefly come from the thyro-laryngeal branch—a collateral of the common carotid (they form plexuses on the vesicle walls) ; the *veins* pass to the jugular. Its *nervous* filaments are from the first and second cervical pairs, with twigs from the sympathetic. It has an abundance of *lymphatics*, which form a system of somewhat large cavities around the alveoli.

FUNCTIONS.—The thyroid body is one of the organs classed, in a somewhat arbitrary manner, in the ill-defined category of ductless glands. Our knowledge of its use is as uncertain at present as in the infancy of anatomical science. So that we can say nothing more on this subject, except that the successive or simultaneous excision of the two lobes in the Horse do not appear to cause any derangement in the animal's health.

In those animals in which it is developed, it seems to have much importance, and is said to play a part with regard to the brain, similar to that attributed to the spleen in the abdominal circulation. Hæmato-poietic functions have also been ascribed to it, from the influence it exerts by means of the follicles placed between its vesicular lobes ; these are supposed to destroy the mucine formed in the body.

The study of its development does not throw any light on its functions.

It is certainly relatively larger in the fœtus and young animals than in adults; but the difference is not sufficiently marked to authorize us in drawing any physiological inductions therefrom.

2. Thymus Gland (Figs. 335, 336).

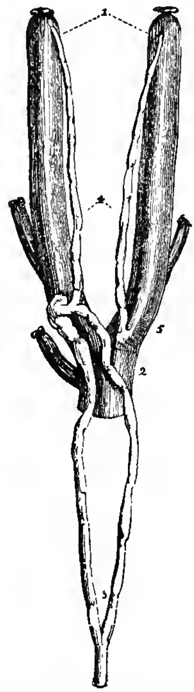
The *thymus gland* is a transitory organ, being only present in the fœtus and very young animals, and in its nature closely resembles the thyroid gland. Like it, it is divided into two lateral lobes, placed close together in the middle line, under

Fig. 335.

PORTION OF THYMUS GLAND OF CALF, UNFOLDED.

a, Main canal; *b*, glandular lobules; *c*, isolated gland granules seated on the main canal.

Fig. 333.



COURSE AND TERMINATION OF THE ABSORBENT DUCTS OF THE THYMUS GLAND OF A CALF.

1, Internal jugular veins; 2, superior vena cava; 3, thoracic duct, dividing into two branches, that again unite before terminating in the root of the left jugular vein; 4, the two thymic ducts: that on the left side opening into the thoracic duct, and the right into the root of the corresponding jugular vein.

the lower face of the trachea, partly without and partly within the chest, between the two layers of the anterior mediastinum. It is elongated from before to behind, of a whitish colour, and uneven or lobulated on its surface like a salivary gland.

Structure.—It owes its uneven aspect to its lobular structure; for it is effectively reduced by dissection into a multitude of granular lobules, in the centre of which are found vesicular cavities containing a lactescent fluid. The vesicles are larger than those of the thyroid gland, and have for walls a very thin layer of delicate connective tissue; they are filled by a mass of nuclei. A wide, irregular cavity has been described as existing in the middle of each lobe (*reservoir of the thymus*), and evidently communicating with the vesicles of the lobules, as it contains a notable quantity of the same milky fluid. This cavity is certainly not present at all periods; for I have not met with it in two young fœtuses now lying before me as I write. But without dwelling on this particular point, we may notice enormous blood-vessels, lymphatics, and nerves, as complementary elements in the organization of the gland, the structure of which is very similar to that of true glands, though differing from them in an important feature—the absence of an excretory duct.

Nothing positive is known as to the functions of the thymus gland; it is only certain that they resemble those of the lymphatic glands, and that they are exclusively related to the development of the young animal; as it generally disappears some months after birth, though it is sometimes found in the adult, and even in very aged animals.

(Its functions are supposed to be the same as, or analogous to, those of the thyroid. Structurally, the organ may be said to consist of an assemblage of hollow glandular lobules joined together by connective tissue, each having a cavity which opens into a central canal that has no duct, and being lined externally by an almost amorphous membrane which divides it into "acini," or gland-granules. Separate acini are often observed on the main canal. Each lobule is made up of its greyish-white, soft parenchyma composed of free nuclei and small cells, and has a minutely distributed capillary plexus. The lymphatics terminate in two large ducts that commence at the upper extremities of the lobes of the gland—the *thymic ducts*—and pass downward to terminate at the junction of the jugular and axillary veins at each side.)

Differential Characters in the Glandiform Bodies annexed to the Respiratory Apparatus in the other Animals.

The *thyroid body*, peculiar to Mammals, is more developed in **Ruminants, Pacyderms,** and **Carnivora,** than in Solipeds. The two lobes are closer together, and are often united by the thyroid isthmus. In the **Pig** this is very marked, and the gland well merits its name, as it forms a veritable shield in front of the trachea, towards the lower part of the neck.

The *thymus gland* in young Ruminants is more voluminous than in the Foal, and is situated higher up in the cervical region. (In the Carnivora, it is divided into two branches; but it is small, and completely lodged between the layers of the anterior mediastinum. It persists for some time after birth, and seldom disappears in less than a year.)

(Comparison of the Glandiform Bodies annexed to the Respiratory Apparatus in Man, with those of Animals.

In **Man,** the two lobes of the *thyroid body* are connected by an isthmus, and the upper extremity of the lobe is carried up to the side of the thyroid cartilage. The isthmus often gives origin to a process of variable length and size, called the *pyramid*, or third lobe, which is generally situated to the left. A muscle is sometimes found connected with the isthmus or pyramid, and is attached above to the body of the os hyoides or to the thyroid cartilage; it has been named the *levator glandulæ thyroidæ*.

The *thymus gland* is composed of two lobes, a right and left, only joined by connective tissue, and having no structural communication. There is a cervical and a thoracic portion, the whole extending from the fourth rib as high as the thyroid gland. After birth it continues to enlarge until the end of the second year, and begins to diminish between the eighth and twelfth years.)

CHAPTER II.

The Respiratory Apparatus in Birds.

THE organs composing the respiratory apparatus of Birds offer conditions altogether special, which have a remarkable influence on the mechanism of respiration. The modifications in the performance of this function will be indicated after an examination of the *tubular apparatus* which carries air into the *lung*, and the characters of that organ, as well as the *air-reservoirs* (or *sacs*) annexed to it.

THE TUBULAR APPARATUS WHICH CARRIES AIR TO THE LUNGS.—When this apparatus is compared with that of Mammals, no very sensible differences are observed—at least, in domesticated Birds.

The nostrils, pierced through the upper mandible of the beak, have no membranous and movable alæ, and the nasal fossæ open into the pharynx by a long, narrow slit behind the bony palate. A transverse row of small, horny papillæ, placed at the anterior extremity of this aperture, represents the soft palate.

The *larynx* has no epiglottis : a defect which does not prevent the complete occlusion of the glottis during the passage of food, as the laryngeal orifice is circumscribed by two lateral lips, which then meet in the most exact manner.

The *trachea* is composed of complete cartilaginous rings, and not simple arcs. In Song-birds, the last ring is a second larynx, the real organ which produces the modulated voice of these creatures ; it only exists in a rudimentary condition in Poultry, however, the last tracheal piece in them being slightly dilated, and showing at the origin of the bronchi a membranous layer, from whose vibration results cries or crowing. Other singular peculiarities belonging to the trachea deserve to be described here, if they were not the exclusive appanage of some wild fowl. We are content to mention the presence of the bony drum found at the terminal extremity of the trachea in the whistling Duck, and the remarkable convolutions that tube forms in the breast-bone of Cranes and male Swans.

The *bronchi* only show incomplete rings in their structure. They pass into the lung by its inferior face, towards the union of its anterior and two posterior thirds. When describing this organ, their mode of ramification, and the nature of the relations they bear to its proper tissue, will be considered.

THE LUNGS.—Sappey, in the remarkable memoir published by him in 1847,[1] has described them as follows : "The lungs of Birds are situated on the lateral parts of the vertebræ of the back—which separate them, and lying against the arch of the thoracic cavity, to which they adhere. Their rosy colour resembles that presented by these organs in Man and the Mammalia during uterine life, and for some time after birth ; they are especially remarkable for their restricted volume, which scarcely represents an eighth part of the thoracic capacity. Their configuration is far removed from the conical form of the lungs in Mammals, and the oval form of the same organs in reptiles ; they are semi-elliptical, and if the two lungs of a Mammal were opposed base to base, their likeness would be produced : to obtain the same results with the lungs of a reptile, it is necessary to divide them in the direction of their great axis.

"This shape enables us to distinguish in the lungs of a bird, *two faces*—a

[1] Sappey, *Recherches sur l'Appareil Respiratoire des Oiseaux*. Paris : 1857

convex and concave; *two borders*—an external and an internal; and *two extremities*—an anterior and posterior.

"The *convex face*, also named the *dorsal*, *costal*, or *superior face*, corresponds inwardly to the dorsal vertebræ, and outwardly to the ribs and the intercostal muscles; it is exactly moulded on the walls of the thorax, and as the ribs protrude on the internal face of these walls, it results that this surface of the lungs is marked by transverse furrows which give it a lobulated aspect; but these lobes or lobules show nothing common with those composing the same organ in Mammalia. In that class, the existence of lobes and lobules is an established fact, and is caused by the dichotomous division of the bronchi; in birds, it is only apparent, and depends on the diminished thickness of the lung at each rib. This face, quite imperforate, is covered by a thin layer of cellular tissue, which unites it to the sides of the thorax.

"The *plane* or *concave* face looks downwards; it is in relation with the diaphragm, which separates it from the viscera of the thorax, and from the abdomen; from this arises its other names of *inferior*, *diaphragmatic*, or *visceral face*. Like the preceding, it is covered by a very fine layer of cellular tissue, which forms adhesions with the diaphragm; but it differs from it by the orifices it presents, which are five in number, and constitute veritable canals, through which the air passes and repasses incessantly to and from the sacs, and from them to the lungs.

"The *borders* are parallel to the axis of the body; the internal is rectilinear, thick, and rounded; the external, convex, thin, and sharp.

"Of the two extremities, the *anterior*, which is very acute, occupies the receding angle. formed by the spine within the first rib without; the *posterior*, more considerable, has a rounded form."

In regard to structure, that which distinguishes the lung of Birds from that of Mammals, is the mode of distribution and termination of the air-passages. In Mammals, the large bronchial tubes, placed in the centre of the lung, send their divisions towards the surface of the organ, or in a centrifugal manner; in birds they are disposed at the periphery of the lung, and direct their different ramifications towards the centre, or in a centripetal fashion. On the other hand, the arboreal division of the bronchi in Mammals is replaced in birds by penniform ramification. Lastly, the terminal bronchial tubes instead of opening into a series of closed vesicles, as in Mammals, anastomose with one another in birds, so as to form an inextricable ærial network.

Sappey has further developed the knowledge acquired on this interesting subject in the following terms: "Arrived in the pulmonary tissue, it (the bronchial trunk) dilates, divides, gradually contracts in following its primary direction, and in this way gains the posterior extremity of the organ, where it terminates by opening into the abdominal reservoir.

"This ærifying trunk, therefore, presents two very distinct portions, the one extra-pulmonary, the other intra-pulmonary. The first offers the greatest analogy to the bronchi of Mammalia; it is membranous internally, elastic and fibrous elsewhere, provided outwardly with cartilaginous rings, which embrace three-fourths of its circumference, and is lined by mucous membrane characterized by its pale rose-colour, and its marked adherence.

"The second differs from the preceding in its dimensions, form, and structure. Owing to its dilatation at its entrance to the lung, its dimensions are more considerable. and may be stated as three to two of the extra-pulmonary portion.

Beyond this enlargement, it diminishes in capacity by the emission of branches, losing its cylindrical form to assume that of a cone with a truncated summit. Its walls are almost entirely destitute of cartilaginous rings, so that the origin of the principal conduits is constantly membranous.

"The air-passages arising from this common trunk to constitute the framework of the lung, are remarkable for their uniformity in number, form, and the direction they offer in all classes of birds. They are generally twelve, and their origin is thus distributed : four arise from the internal wall of the trunk by a series of orifices placed one after the other ; seven are detached from its external wall by a second series of orifices also disposed in rows ; the twelfth springs from its inferior wall, and immediately bends downwards and outwards to open into the posterior diaphragmatic reservoir, which may be considered as a terminal branch of the principal trunk.

"All the canals which have their origin from these linear series of openings on the internal and external walls of the generating trunk, show this common disposition : that from their commencement they pass towards the periphery of the lung, that they divide and subdivide at this periphery, that they cover it with their ramifications, and do not leave it to enter the pulmonary parenchyma until their volume has been considerably reduced.

"The conduits leaving the orifices situated on the inner wall of the ærial trunk ramify on the inferior face of the lung ; those proceeding from the echeloned orifices on the outer wall are distributed on the opposite face. The first constitute the diaphragmatic, and the second the costal bronchial tubes.

"The *diaphragmatic bronchial tubes*, four in number, like the orifices from which they originate, may be distinguished by the numerical names of first, second, third, and fourth, in proceeding from before to behind ; the first bronchus is carried forward horizontally, the second transversely inwards, the third obliquely inwards and backwards, and the fourth directly backwards. In view of their divergent direction, which resembles a fan, they might be designated as the anterior, internal, and posterior diaphragmatic bronchial tubes ; and to distinguish the last two, the more voluminous one—which is directed backwards and inwards—might be named the great posterior diaphragmatic bronchus, and the one passing directly backwards, the small posterior diaphragmatic bronchus.

"The *costal bronchial tubes*, seven in number, may be also designated as first, second, third, etc., in proceeding from before to behind. Parallel at their origin, and in juxtaposition, like the pipes of an organ, they separate after following a certain course, and affect, by their divergence, the fan-shape already observed in the disposition of the diaphragmatic bronchi. Like the latter, they become peripheral from their origin, and spread out from centre to circumference. The first is carried very obliquely upwards and inwards, to attain the anterior extremity of the lung ; all the branches it furnishes arise from its anterior wall, and those which are nearest its origin are inflected to gain the external border of the organ. The succeeding tubes are directed forwards, the others forwards and inwards ; while all proceed to meet those coming from the anterior diaphragmatic bronchus, though they do not anastomose with them. Coming in contact, they plunge into the pulmonary tissue in such a way, that, when a lung is inflated, we observe between these two orders of ramifications a very manifest groove, which is perfectly distinct from those due to the protrusion of the ribs ; this groove evidently represents, though in a rudimentary state, the interlobular fissures in the lungs of quadrupeds.

"The second, third, and fourth costal bronchi follow a transverse course, and ramify on the inner border of the lung; the fifth and sixth incline towards the posterior extremity of the organ; the seventh, very small, reaches this extremity and disappears.

"The first costal bronchus is the most voluminous; those succeeding it gradually diminish in calibre. At their point of emergence they adhere closely to the ribs; all are imperforate, and this feature essentially distinguishes them from those occupying the opposite face.

"The *canaliculi* furnished by these principal tubes do not sensibly differ in calibre in the various bronchi; all offer an equal diameter, and their dimensions are only in relation to the total volume of the lung. All are detached at a right angle from the pulmonary wall of each bronchus, and descend perpendicularly into the lung; and all, from their origin to their termination, preserve the same diameter, and consequently the same cylindrical form. If this mode of ramification be compared with that observed in Mammals, it will be seen to differ considerably. In the latter class, the air-passages affect the dichotomous division proper to the arteries and veins, the result of which is a series of arborescent canals decreasing in capacity. In birds only two kinds of conduits are observed, the primitive and peripheral, disposed around a generating axis like the barbs of a feather on their stalk; and the secondary and parenchymatous, implanted on the pulmonary walls of the first, like the hairs of a brush on their common base. These two arrangements are evidently similar, except that the peripheral canals, which are few, only form a single row on each side; while the canaliculi, very numerous, form several. Consequently, it may be said that the mode of ramification proper to Mammalia is essentially dichotomous, and that observed in birds essentially penniform.

"Independently of the canaliculi arising from the pulmonary walls of the diaphragmatic and costal bronchi, there are others which spring directly from the generative trunk; but in their dimensions, direction, form, and general disposition, they do not differ from the preceding.

"How do these canals terminate? Notwithstanding the importance of this question, it has been generally neglected; though its solution alone may furnish the analogies and differences necessary for the parallel which has always been attempted to be established between the lungs of birds and those of other vertebrates. Our special researches on this point have led us to the conclusion that all the canaliculi open into one another, and by this anastomosis constitute an extricable plexus the various parts of which communicate with each other."

Finally, it may be mentioned that "the walls of the pulmonary canaliculi examined microscopically, appear to be covered internally with irregular septa which circumscribe the areolæ, and give them a cellular aspect."

THE AIR-SACS.[1]—"In birds, the pulmonary mucous membrane is continued, at the level of the orifices in the lung, into the utriculiform cavities which are developed between the walls of the thorax and the abdomen on the one side, and the thoracic and abdominal viscera on the other. These air-reservoirs exist in all the vertebrata of the second class. In all, they are situated at the periphery of the viscera in the trunk, in such a manner that Carus has justly observed that the lungs of Birds enclose all the other viscera; so that when they are distended by the entrance of air, they generally depress these viscera by pushing them

[1] What is said relating to these air-sacs is taken from the Memoir of M. Sappey, *Recherches sur l'Appareil Respiratoire des Oiseaux.* Paris: 1847.

towards the median plane. In all, they are independent of each other, and freely communicate either with the lung by a single aperture, or with the bones by one or more openings. Lastly, in all they are nine in number.

"These reservoirs are: the *thoracic sac,* situated at the anterior part of the thorax; two *cervical reservoirs,* situated at the base of the neck; *two anterior diaphragmatic reservoirs,* placed between the two diaphragms; *two posterior diaphragmatic reservoirs,* also between these two diaphragms, but behind the preceding; and, lastly, *two abdominal reservoirs,* placed against the superior wall of the abdomen. Of these nine reservoirs, the first only is single and symmetrical; the others are pairs, and similarly arranged on each side of the median plane.

"The thoracic and cervical reservoirs are situated beneath, and in front of, the lungs; the abdominal reservoirs lie behind these organs, and the four diaphragmatic sacs at their inferior part and between the preceding; hence the denomination of middle reservoirs sometimes applied to the latter, in opposition to the first, which are named the anterior reservoirs, and to the second, called the posterior reservoirs."

External Conformation of the Reservoirs.—1. *Thoracic reservoir* (Fig. 337, 2).—"It is situated above the clavicles and the inter-clavicular space, in the cavity of the thorax, which it extends beyond on each side to the roots of the wings, around the articulation of the shoulder. It is related with: above, the trachea and œsophagus on the middle plane, the lungs and the origin of the cervical reservoirs on the lateral parts; below, with the sternum, the clavicles, and the interclavicular aponeurosis; behind, with the heart and anterior diaphragmatic reservoirs, beneath which it is prolonged by forming on each a long point; in front, with the integuments of the neck, which it raises into a hemisphere in Palmipeds, but which is angularly depressed in other classes; on the sides, with the sternal ribs, the two clavicles, and the membrane uniting them.

"The prolongations which arise from the lateral parts of these reservoirs, and cross the walls of the thorax to pass around the articulation of the shoulder, are three in number, and may be distinguished into inferior or subpectoral, superior or subscapular, and middle or humeral.

"The *subpectoral prolongation* (Fig. 337, *d*) issues from the thoracic reservoir by an orifice situated behind the posterior clavicle, and passes beneath the tendon of the great pectoral muscle, where it spreads out as a lenticular cavity. The relations it contracts with that muscle are remarkable: in Birds, still more than in Man and a great number of quadrupeds, the tendon of the great pectoral is formed of two parts, one direct, the other reflected; it is between these two portions that this small air-sac is insinuated, and where it forms a very firm connection with them; the effect of which is, that at the moment the great pectoral muscle contracts, it dilates the subjacent cell and draws into it a greater quantity of air.

"The *subscapular* and *humeral prolongation* communicate with the principal reservoir by a common opening placed behind the small adductor muscle of the humerus. After leaving this orifice, the subscapular sac spreads under the scapular and subscapular muscle, which it separates from the ribs and corresponding intercostal muscles; it is developed more particularly in a longitudinal direction.

"The humeral prolongation occupies the axilla; it is smaller than the preceding, of a pyramidal form, and opens by its summit into an infundibular fossa, which leads to the canal of the humerus.

"The thoracic reservoir differs from all the others by the extremely numerous membranous folds which partition its cavity. The membrane forming it being continued on itself, every organ traversing the thorax becomes the cause of a fold in which it is imprisoned; and as the thoracic cavity is traversed by the trachea and the œsophagus, the muscles which move the inferior larynx, and the arteries and veins, it will be understood how this reservoir should become irregular in consequence of these various partitions, and also why the other ærial sacs situated between the viscera and the walls of the thorax, or the simple contiguous surfaces, should preserve their regular and proper form.

"The thoracic reservoir communicates with the lungs by an infundibular orifice, situated on the external side of the embouchure of each bronchus. This orifice is dilated during inspiration, by the contraction of the two first fasciculi of the pulmonary diaphragm."

2. *Cervical reservoirs* (Fig. 337, 1, 1).—"They are situated above the preceding, and the inferior part of the neck and anterior part of the lung; inflated after removal from the neighbouring parts, they resemble two cones, whose rounded base looks forwards, and whose pediculated summit is directed backwards.

"Superiorly, these reservoirs lie against the cervical muscles; inferiorly, they correspond to the air-sac of the thorax, from which they are separated by the trachea, the œsophagus, the pneumogastric nerves, and the jugular veins. Inwardly, they are in juxtaposition, and consequently form a median septum which includes in its substance the two common carotid arteries. Outwardly, they are related to the origin of the cervical nerves, to each of which they furnish a small sheath, and with the vertebral artery which they surround, but do not contain in their cavity, as well as with a subcutaneous muscle and the skin. By their summits, they communicate with the anterior diaphragmatic bronchus; and by their base they send out a prolongation which conducts the air into all the vertebræ of the neck and back, into all the vertebral ribs, and, finally, into the spinal canal.

"In their cervical portion, these prolongations present themselves in the form of two canals extending from the base of the cervical reservoirs to the base of the cranium, where they terminate; parallel and contiguous to the vertebral arteries, like them they are lodged in the canals excavated in the substance of the transverse processes.

"From their external part arises, at the six last cervical vertebræ, as many diverticuli, which, lying against each other, pass from each side in the muscles of the neck, surrounded by a common fibrous envelope, and apparently form a kind of canal at the inferior part of this region; when, however, this fibrous membrane is removed, it becomes easy to isolate them, and it is then seen that they are completely independent, and resemble small cornua. Highly developed in Palmipeds, they are only present in a rudimentary state in the other classes.

"On the internal side of these conduits, we see, at the level of each vertebra, one or more orifices by which the air enters their interior; and at the inter-vertebral foramina another orifice, which allows it to pass into the spinal canal. From the communication established by these orifices between the respiratory apparatus and the spinal canal, it follows that in Birds the cervical region is traversed by three atmospherical currents—two lateral or intertransverse, parallel to the vertebral arteries; the third median of interspinal, parallel to the spinal cord.

"Just as the medullary tissue is replaced by air in the bones of Birds, so might it be imagined that the sub-arachnoidean fluid was also replaced by air around their spinal cord; and observation justifies the correctness of this prevision. The dura mater, whose capacity is so superior to the volume of the marrow in Mammals, exactly measures the volume of that organ in Birds; so that there does not exist between the fibrous and nervous surfaces any space for an accumulation of liquid: this anatomical fact is sufficient to demonstrate the absence of sub-arachnoidean fluid in Birds. In denying the existence of this fluid, it ought to be added that in this class of vertebrata, as in the preceding, the spinal prolongation is covered by a triple envelope; that in each, between the pia mater and dura mater, is found a thin transparent membrane, which is lubricated by a serous fluid; but here this fluid does not collect, it only moistens the arachnoid membrane.

"Considered in their dorsal portion, the prolongations springing from the cervical reservoirs offer an entirely different arrangement to that already noticed. The interspinal current, having entered the thorax, terminates by passing into the first dorsal vertebra; after coursing through every part of this vertebra, it escapes by a lateral orifice into a small sac situated between the two first ribs, at the origin of the first dorsal nerve; from this sac, it passes into the second vertebra by an opening placed on its antero-lateral part, then it flows back from this into a new air-sac developed between the second and third ribs; and passing in the same manner into the third vertebra to sweep through a third intercostal sac, it arrives nearer and nearer the last dorsal vertebra. In their dorsal portion, the prolongations emanating from the cervical reservoirs thus form two currents, though these are constituted alternately by the vertebræ and the small air-sacs placed on their lateral aspect. At the same time that these sacs receive the air from the vertebræ preceding them, and transmit it to those which follow, they communicate it to all the vertebral ribs.

"In no order of Birds do the ærial currents leaving the cervical reservoirs communicate with those which circulate in the cranium. Liquids injected either by the ærial portion of the vertebral canal or the lateral prolongations of the neck, never enter the bones of that cavity. Thinking that the injection might perhaps penetrate if passed in the opposite direction, we have perforated the bones of the cranium, and to the aperture have adapted the extremity of a steel syringe filled with mercury; but the metal did not reach the ærial prolongations of the neck. From this double experiment, we concluded that the cranial bones have no communication with the respiratory apparatus."

3. *Anterior diaphragmatic reservoirs* (Fig. 337, 3).—"Placed between the two diaphragms, they correspond: in front, to the thoracic reservoirs, against which they stand; behind, to the posterior diaphragmatic reservoirs; outwardly, to the ribs and intercostal muscles; inwardly, to the thoraco-abdominal diaphragm and œsophagus; below, to the most distant part of the thoracic reservoir; above, to the pulmonary diaphragm, which separates them from the corresponding lung. These air-sacs communicate with the lungs by a circular opening, which originates from the great posterior diaphragmatic bronchus; there is often a second opening of communication beyond the embouchure of the trunk; this reservoir is the only one which receives air from the lung by a double orifice."

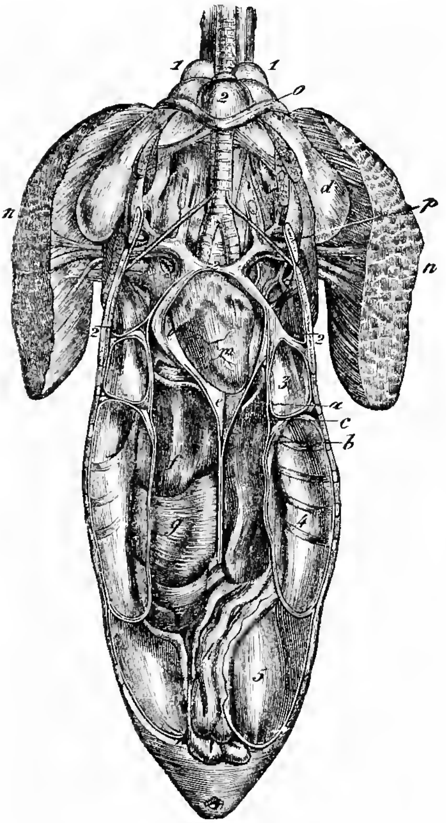
4. *Posterior diaphragmatic reservoirs* (Fig. 337, 4).—"Oval-shaped like the preceding, and situated like them in the interval which separates the two diaphragms, these air-sacs are in contact, by their anterior part, with the anterior diaphragmatic reservoirs, with which they form a vertical and trans-

verse septum. Sometimes this septum is carried a little more forward, and then the anterior reservoir is smaller; this is most frequent in Palmipeds. At other times it inclines backwards, and the anterior reservoir is larger; this arrangement is peculiar to the Gallinacæ. And, lastly, this partition divides the intercepted space between the diaphragms into two equal cavities: rapacious Birds offer numerous examples of this.

"Behind, these reservoirs stand against the abdominal sacs, from which they are separated by the thoraco-abdominal diaphragm; below, they respond to the sternal ribs and the lateral parts of the sternum; above, to the pulmonary diaphragm; inwards, to the thoraco-abdominal diaphragm; outwards, to the vertebral ribs and intercostal muscles.

"A parabolic opening, situated in the middle part of the external border of the lung, or a little more behind, establishes their communication with that organ. This orifice, which is remarkable for its great dimensions, occupies the extremity of a voluminous bronchial tube which follows the direction of the generating trunk, and in such a manner that this trunk appears to pass directly towards the posterior diaphragmatic reservoir, and to open as a canal."

Fig. 337.



GENERAL VIEW OF THE AIR-RESERVOIRS OF THE DUCK, OPENED INFERIORLY; ALSO THEIR RELATIONS WITH THE PRINCIPAL VISCERA OF THE TRUNK.

1, 1, Anterior extremity of the cervical reservoirs; 2, thoracic reservoir; 3, anterior diaphragmatic reservoir; 4, posterior ditto; 5, abdominal reservoir. *a*, Membrane forming the anterior diaphragmatic reservoir; *b*, membrane forming the posterior ditto. 6, Section of the thoraco-abdominal diaphragm. *d*, Subpectoral prolongation of the thoracic reservoir; *e*, pericardium; *f*, *f*, liver; *g*, gizzard; *h*, intestines; *m*, heart; *n*, *n*, section of the great pectoral muscle above its insertion into the humerus; o, anterior clavicle; *p*, posterior clavicle of the right side cut and turned outwards.

6. *Abdominal reservoirs* (Fig. 337, 5).—"The two air-sacs situated in the abdomen present themselves, when inflated, as two enormous bladders, the capacity of each differing but little from the volume of the trunk. Situated between the superior and lateral parietes of the abdomen on one side, and the abdominal viscera on the other, they cannot be dilated without driving the intestinal mass downwards and inwards.

"Their anterior extremity, continuous with the lung, is somewhat inflected to pass under the fibrous arch extending from the spine to the pelvis.

"Their posterior extremity, dilated and voluminous, responds to the cloaca. Outwardly, they adhere by cellular tissue to the thoraco-abdominal diaphragm, the parietes of the abdomen, and those of the pelvis. Inwardly, they are in contact with the intestinal mass and the testicles or ovaries. Below and in front, they rest on a fibrous septum, which in all birds divides the abdominal cavity into two smaller cavities : one anterior, which represents the abdomen and lodges the liver, the other posterior, which represents the pelvis and contains the stomach and intestines. This fibrous septum is extremely remarkable in large birds, particularly the Ostrich, in which it has been described by Perrault as a transverse diaphragm ; it is inserted into the entire circumference of the pelvic bones, and sustains the stomach as well as the intestinal tube. Below and behind, the abdominal reservoirs lie on the intestines. Above, these sacs cover the inferior face of the kidneys, and there furnish three prolongations : 1. A supra-renal prolongation. 2. Two femoral prolongations.

"The supra-renal prolongation leaves the principal reservoir at the postero-external part of the kidneys; from thence it passes obliquely upwards and forwards, to spread over the superior surface of the kidney, which it depresses when the abdominal sac is inflated. Arrived at the internal border of the kidneys, these prolongations are introduced between the transverse processes of the sacral vertebræ, and ascend from behind forwards to the height of the two first dorsal vertebræ, forming two triangular canals situated above the sacrum, in the sacral channels, and separated from one another by a series of corresponding spinous processes. The supra-renal prolongations are not present in all birds; they are particularly observed in the Gallinacæ and diurnal rapacious birds. In some Palmipeds—the Swan, for example—they are equally developed; in the Ostrich, they are replaced by the supra-spinal canals.

"The femoral prolongations are two in number—an anterior small and a posterior large ; they arise from the abdominal reservoir at the cotyloid cavities, and leave the pelvis in traversing the bony opening through which the crural vessels pass ; after clearing the limits of these cavities, they spread around the coxo-femoral articulation, and terminate in a cæcum in the majority of birds. In diurnal birds of prey, they communicate with the femoral canal by an orifice situated at the anterior part of the great trochanter. These prolongations, very developed in the Ostrich, also open in it into the femoral cavity ; it is not without surprise that we see this arrangement, which is peculiar to birds remarkable for their rapidity and power of flight, also present in those to which ærial locomotion has been entirely denied. The abdominal reservoirs communicate with the lung by an orifice situated beneath the fibrous arch of the diaphragm, and disposed like the rose of a watering-can."

Communication of the Reservoirs with the Bones.—"The communications of the respiratory apparatus with the skeleton in birds are extremely numerous. We will successively examine those belonging to each reservoir.

"The bones which receive air from the thoracic reservoir are : 1. The anterior clavicle, which is perforated at its two extremities. 2. The posterior clavicles, which are also perforated a little below their scapular extremity. 3. The sternum which presents two series of openings—the middle ones that conduct the air into the sternal ridge, and the lateral ones, very small, six to eight in number, corresponding to the intercostal spaces. 4. The scapulæ, which offer one or more apertures at their anterior extremity, and receive the air for the subscapular prolongation. 5. The humerus, which obtains the air for the humeral prolongation by a fossa situated at the inferior and internal part of its articular head. 6. The sternal ribs, which allow the atmosphere to penetrate by small openings at their inferior extremities. To sum up, eight bones, without reckoning the sternal ribs, whose number varies, receive the air which fills them from the thoracic reservoir.

"The cervical reservoirs conduct the air. 1. To all the cervical vertebræ. 2. To all the dorsal vertebræ. 3. To all the vertebral ribs. The vertebræ of the neck are ærated in their anterior part by the currents which accompany the vertebral artery, and in their posterior part by the interspinal current. The first obtain entrance to the anterior segment by one or more orifices made in the inner wall of the intertransverse canals; the median current penetrates the posterior segment by two orifices, a right and left, situated on the inner and medullary wall of that segment. The first vertebra of the back is provided with air in the same manner, by the middle and lateral currents of the neck. This air, after passing through the first vertebra, leaves by its lateral parts to enter a small sac; from this it goes into the superior part of the second vertebra, escapes from this by its lower portion, to be received into a lateral sac, and so on to the last dorsal vertebra. These sacs also supply the vertebral ribs with air, which enters them by very small apertures situated at their spinal extremity.

"The diaphragmatic reservoirs have no bony communications. The abdominal reservoirs supply: 1. The sacrum. 2. The coccygeal vertebræ. 3. The iliac bones. 4. The femurs. The air traversing the sacrum, coccyx, and ileum, comes directly from the supra-renal prolongations, and that filling the femoral cavity from the femoral prolongations. In this enumeration of the communications between the skeleton and the respiratory apparatus, we have taken as a type the most ærated skeleton: that of diurnal birds of prey, like the eagle, kite, hawk, etc.; the bones which communicate with the air-sacs are not so numerous in the other classes. In this respect, they may be ranged in three categories: 1. Those which are æriferous in all classes. 2. Those in certain classes only. 3. And those which are not so in any class. The bones always ærated are the cervical and dorsal vertebræ, the sternum, and we may add the humerus, though it is not so in the Ostrich. Those ærated in some classes only are: the furculum, clavicles, scapulæ, vertebral and sternal ribs, the sacrum, coccyx, and femurs. And the bones which are never ærated are those of the forearm and hand, the leg and foot."

Structure of the Reservoirs.—The walls of these cavities are essentially formed by a thin cellulo-serous membrane, strengthened in some places by an external envelope of elastic fibrous tissue. Long, thin blood-vessels are distributed to the substance of these walls; they do not belong to the pulmonary, but to the general circulation, the arteries being derived from the aorta, and the veins opening directly or indirectly into the venæ cava. No lymphatics have been found in the air-sacs.

Mechanism of Respiration in Birds.—The anatomical arrangement described above differs in so many respects from that existing in Mammals, that it ought to bring about important modifications in the mechanism of respiration. It does not come within our scope to write the history of these modifications; but we cannot dispense with indicating, in a summary way, their principal characters, in order to make known in a general manner the signification of the special organization this apparatus offers in birds.

We remark, in the first place, that the slight mobility of the vertebral ribs, and the adhesion of the lung to their inner face, only allows of a very slight dilatation of that viscus during inspiration. And the entrance of air into the pulmonary tissue is not due to this dilatation ; it is due to the dilatation of the diaphragmatic reservoirs ; the position of these effectively admits of their expansion, by the play of the inferior on the superior ribs. The air is then drawn into their cavity after traversing the larger bronchial tubes which open into them, and also after passing across a certain region of the capillary network formed by the canaliculi, where it comes into mediate contact with the blood, and is submitted to the necessary transformations. The atmosphere, therefore, arrives in the diaphragmatic sacs partly pure and partly altered by its contact with the blood. During expiration, it again resumes the course it followed on its introduction, traverses a second time the lung, and is thus respired once more before being expelled from the body. It is, therefore, obvious that the hæmatosic transformations accomplished in the lung take place during the two acts of respiration—inspiration and expiration.

In studying the part that the other reservoirs play in this function, Sappey has been able to prove that they act as antagonists to the first, by contracting during inspiration and expanding in expiration. No doubt, at the time of the contraction of the middle reservoirs, a small quantity of the air they contain is driven back into the anterior and posterior sacs in passing across the lung ; and without doubt, also, these latter give a part of their contents to the diaphragmatic sacs at the moment of the expansion which draws the air into these reservoirs. Sappey has also noted that these contents are always formed of entirely vitiated air, while the air of the middle reservoirs has only been partially respired.

It is necessary to add that the functions of the air-sacs do not cease here ; for it has been demonstrated that they exercise a very marked influence : 1. On locomotion, by diminishing the weight of the body, and, by their position, rendering equilibrium more stable. 2. On the voice, the range and power of which they augment.

BOOK IV.

THE URINARY APPARATUS.

THIS apparatus, though simple, yet plays a very important part in the animal economy, as it is charged with the duty of eliminating from the blood—along with the superfluous water and other accessory substances—the excrementitial nitrogenous products resulting from the exercise of the vital functions. These products we find in the urine—the liquid secreted by the *kidneys*, and which is carried by the *ureters* into a special reservoir—the *bladder*—where it accumulates, and whence it is expelled from the body by the *urethral canal*, at periods more or less distant, according to the requirements of the animal.

The *kidneys*, the essential organs of urinary depuration, will be first studied; then the *excretory apparatus*; and, finally, a brief notice will be given of the *supra-renal capsules*—small bodies annexed to the kidneys, the function of which is not yet determined.

Preparation.—Place the animal in the first position, and remove one of tho posterior limbs. Take out the intestines adopting the precautions indicated at page 455. Saw through the pelvic symphysis, as well as the neck of the ilium on the side opposite the remaining abdominal limb, removing the coxal portion between these sections. The pelvic cavity being now opened, the urinary apparatus is exposed, and to complete the preparation it is necessary to: 1. Remove the peritoneum, to show that the urinary apparatus is situated external to that membrane. 2. Free the ureters and kidneys from the cellulo-adipose tissue surrounding them, but retaining the vessels of the latter, and leaving undisturbed their relations with the pancreas and supra-renal capsules. 3. Inflate the bladder, and dissect its neck, taking care to preserve the orbicular peritoneal fold which envelops its anterior *cul-de-sac* (or *fundus*).

In the male, the inflation of the bladder is very simple, and requires no directions. In the female, however, it is requisite first to close the meatus urinarius, which is accomplished by drawing its two lips towards the entrance to the vulva, by means of two chain-hooks, passing two pins through their mucous membrane, and tying a ligature behind these; the bladder is then inflated by the ureter.

Independently of this dissection *in situ*, it is advisable to examine the urinary apparatus when isolated, and laid arranged upon a table, as in Fig. 338. We can then study: 1. By dissection, the structure of the kidneys and arrangement of the pelvis renalis. 2. The mode of termination of the ureters. 3. The interior of the bladder.

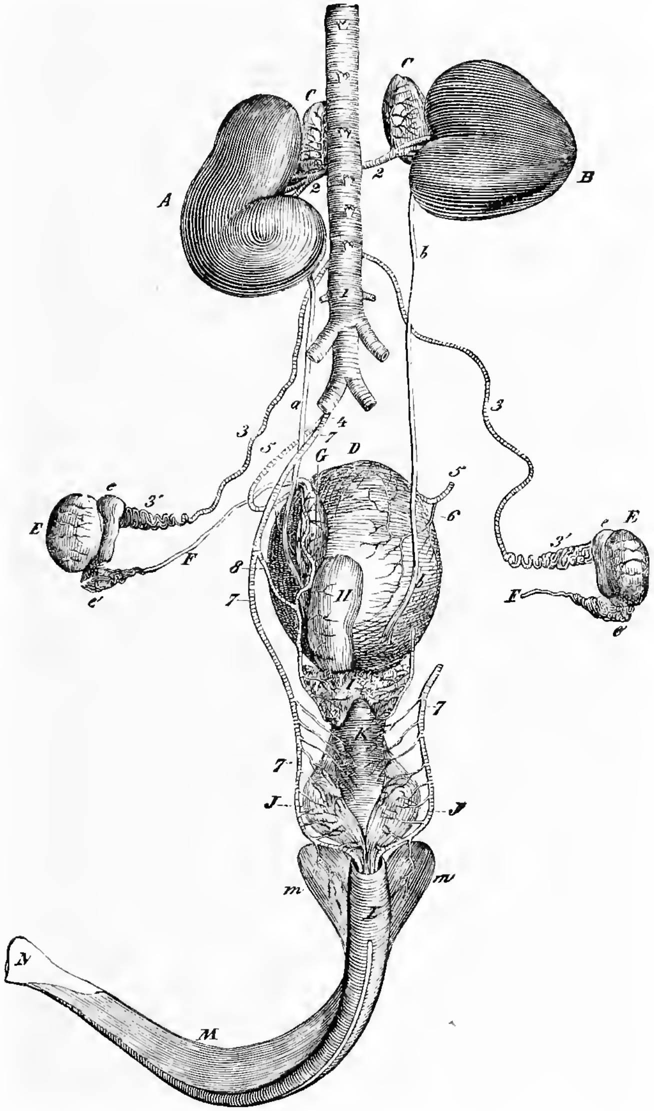
1. THE KIDNEYS (Figs. 258, 338).

Situation.—These are two glandular organs situated in the abdominal cavity, to the right and left of the sublumbar region, lying against the great psoas muscles, and maintained in that position: 1. By an envelope of cellulo-adipose tissue. 2. By the peritoneum, which passes beneath them. 3. By the pressure of the digestive organs contained in the abdominal cavity.

Their *situation* is not absolutely alike, for the *right* comes forward to beneath the two last ribs, while the *left* scarcely reaches beyond the eighteenth rib. The latter is, therefore, more posterior than the former.

External conformation.—Studied *externally*, the kidneys present a special form, which often serves as a term of comparison, and resembles more or less that of a haricot bean, or the heart on a playing-card. The latter configuration

Fig. 338.



SUPERIOR AND GENERAL VIEW OF THE GENITO-URINARY APPARATUS IN THE MALE, WITH THE ARTERIES.

A, Left kidney; B, right kidney; *a*, *b*, ureters; C, C, supra-renal capsules; D, bladder; E, E, testicles; *e*, head of the epididymus; *e'*, tail of the epididymus; F, deferent canal; G, pelvic dilatation of the deferent canal; H, left vesicula seminales (the right has been removed, along with the deferent canal of the same side, to show the insertion of the ureters into the bladder); I, prostate; J, Cowper's glands; K, membranous, or intra-pelvic portion of the urethral canal; L, its bulbous portion; M, cavernous body of the penis; *m*, *m*, its roots; N, head of the penis. 1, Abdominal aorta; 2, 2, arteries (renal) giving off the principal capsular artery; 3, spermatic artery; 4, common origin of the umbilical and arteries of the bulb; 5, umbilical artery; 6, its vesical branch; 7, internal artery of the bulb; 8, its vesico-prostatic branch.

is most frequently noticed in the right kidney, the left being generally like the first.

Flattened on both sides, the kidneys show two perfectly smooth faces, the inferior of which always exhibits a variable number of furrows that lodge the arteries; the right kidney has always a special furrow for the ureter. Each kidney has a circumference divisible into three borders, only the internal of which offers a certain interest. This is deeply notched, to form the *fissure* or *hilus* of the kidney, which lodges the vessels and nerves of the organ, as well as the origin of the ureter.

Weight.—The kidneys vary much in weight in individuals. The right is always more voluminous and heavy than the left, its average weight being 27 ounces, while that of the last is 25 ounces.

Relations.—The *relations* of these two glands with the neighbouring parts ought to be particularly examined. The right kidney is related, by its upper face, to the great psoas muscle, the muscular portion of the diaphragm, and to the last, or even the second-last rib. Its inferior face, incompletely covered by peritoneum, adheres, for the greater part of its extent, either to the pancreas and supra-renal capsule, or to the base of the cæcum, by means of a loose and abundant connective tissue. The internal border is in contact with the posterior vena cava and the small psoas muscle; the anterior, with the base of the right lobe of the liver and the lobule of Spigel (*lobus caudatus*), through the medium of the peritoneum; the posterior border is enveloped in peritoneum. The *left kidney* has, by its superior face, the same connections as the right, except in its relation with the second last rib. Its inferior face is almost entirely covered by peritoneum, and is related, in front and inwardly, to the supra-renal capsule. The internal border is margined by the aorta; the anterior touches the base of the spleen and the left extremity of the pancreas; the posterior is, like the inferior face, in contact with the serous membrane of the abdominal cavity.

Internal conformation.—If a horizontal section is made of the kidney, it will be found to possess a cavity called the *renal basin* (or *pelvis*), into which the urine secreted by the gland flows, and at which the ureter commences. Placed in the middle of the kidney, near the hilus, the pelvis is elongated before and behind, and depressed from above to below. Within it is remarked a wide infundibulum—the origin of the ureter (the *sinus renalis*). Opposite to this funnel-shaped space is a very prominent crest (*renal crest*) that runs along the whole length of the external side of the pelvis, and on which are noticed the orifices of the uriniferous tubes; these, by pressing the tissue of the kidney with the fingers, can be made to pour out the urine accumulated in them. The renal cavity forms some very small diverticuli opposite the infundibulum, the largest of which—situated before and behind the latter—are named the *arms of the pelvis.*

This cavity is lined by a transversely plicated mucous membrane, continuous with that of the ureter, and is covered with the epithelium of the uriniferous tubes which open on the border of the crest. At these folds, the mucous membrane contains small racemose glands lined by two layers of cells (Paladino and Egli).

STRUCTURE.—The kidneys present for study in their structure: 1. An *enveloping tunic*. 2. Their *proper tissue*. 3. *Vessels* and *nerves*.

1. **Enveloping Tunic.**—This is a fibrous membrane, intimately united to the proper substance of the kidney, into which it sends a multitude of prolongations, and is folded around the blood-vessels in such a manner as to form sheaths,

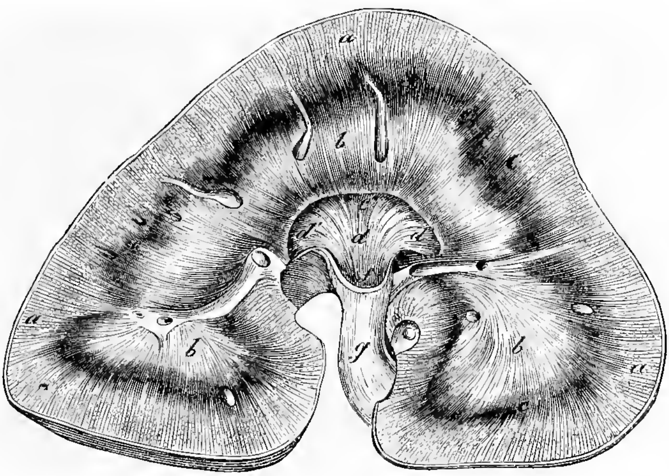
which enter with them into the organ. (Some authors—among them Leyh—describe, in addition to this *capsula propria*, a thin layer formed by the condensed areolar matrix of the kidney, from which it can be easily torn.)

PROPER TISSUE.—The glandular tissue of the kidneys (*areola parenchyma*, or *matrix*) has, externally, a reddish-brown colour, more or less deep in different individuals. It is dense and friable, and easily torn when deprived of its fibrous capsule. Its substance is not everywhere homogeneous: very dark-coloured externally, where it forms the *cortical layer*, it becomes whiter around the pelvis, where it constitutes the *medullary layer*; where the latter comes in contact with the former, and sometimes even near the pelvis, it assumes a tint like that of wine.

These two portions are not well defined, but penetrate each other reciprocally, so as to compose, at their point of junction, irregular festoons, very readily perceived in a horizontal section of the kidney (Fig. 339).

The cortical is also distinguished from the medullary substance by its granular

Fig. 339.



HORIZONTAL LONGITUDINAL SECTION OF THE HORSE'S KIDNEY.

a, Cortical (or vascular) portion; *b*, medullary (or tubular) portion; *c*, peripheral portion of the latter; *d*, interior of the pelvis; *d'*, *d'*, arms of the pelvis; *e*, border of the crest; *f*, infundibulum; *g*, ureter.

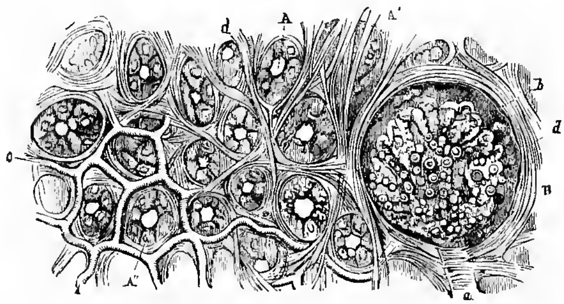
aspect, and the presence of minute, reddish spheres, readily visible to the naked eye, and named *Malpighian corpuscles*; while the medullary substance appears to be composed of radiating fibres.

In the Horse, the tissue of the kidney cannot be divided into lobules or pyramids; to the naked eye it appears to be composed of fibres that start from every part of its exterior, and converge towards the crest of the pelvis. A microscopical examination demonstrates these fibres to be canals or tubes; hence they are designated *tubuli uriniferi*, or *Bellini's tubes*. A delicate connective tissue—a kind of *stroma*, which is very rare in the cortical, but more abundant in the medullary substance, especially in the vicinity of the pelvis—sustains the vessels and nerves, and unites the tubuli uriniferi to each other.

The *tubuli uriniferi* are constituted by a proper amorphous membrane, very thin and elastic, the internal face of which is lined by simple epithelium that readily alters ; the cells are polygonal in certain points, polyhedral in others, and transparent or granular.

The uriniferous tube has not everywhere the same direction or diameter. Taking it at its termination on the crest of the pelvis, and following it to its origin in the Malpighian body, it is found that the tubule is at first single, straight, and voluminous, but that during its course across the medullary substance it divides into three or four tubes, which, in their turn, subdivide in a dichotomous manner. These divisions are less voluminous and *straight* (collected in bundles, they are the *pyramids of Ferrein*), but their diameter is uniform until they reach the cortical substance ; here they bifurcate, each branch becomes flexuous, and is designated the *uniting* or *junctional tube*, and is continued in a kind of elongated U shape—the *looped* or *ansiform tube of Henle*—which descends towards the centre of the kidney. The ascending branch of this ansiform tube—the diameter of which is very small—suddenly dilates on entering the cortical substance, describes several bends, contracts into a narrow neck, and

Fig 340.



SECTION OF THE CORTICAL SUBSTANCE OF THE KIDNEY.

A, A, Tubuli uriniferi divided transversely, showing the spheroidal epithelium in their interior; B, Malpighian capsule; *a*, its afferent branch of the renal artery ; *b*, its glomerulus of capillaries, *c*, *c*, secreting plexus formed by its efferent vessels, *d*, *d*, fibrous stroma.

then opens into a Malpighian body, after having taken the name of *convoluted tube*.

The *corpora Malpighiana* (or *capsules*) are minute vesicles, the walls of which possess the same structure as the uriniferous tubes ; each lodges a cluster of arterial capillaries or *renal glomerulus*, and has two opposite openings : one communicating between the corpora and convoluted tubes, the other affording a passage to the afferent and efferent vessels, which serve to irrigate a tuft of capillaries forming the glomerulus of Malpighi. Between the membrane proper and the glomerulus are two layers of epithelium—an external continuous with that of the uriniferous tube, and an internal applied directly to the glomerulus and forming a kind of hood over it (lining *Bowman's capsule*).

3. VESSELS AND NERVES.—*a*. The kidney possesses a special *artery* and *vein*, remarkable for their enormous volume.

a. The *artery* (the *renal*) forms several branches that reach the kidney by its inner border and inferior face, and divide into a certain number of principal vessels, which are disposed in a wavy manner on the limits of the cortical and medullary substances. From them are given off branches to each of these substances, and among those distributed to the cortical are some regularly disposed, which furnish, on each side, the glomerule ramifications ; these are the *afferent vessels*, or *Malpighian glomerules* (or *tufts*) ; the others form a polyhedral plexus around the convoluted tubes and corpora Malpighiana. The *afferent vessels* of the renal glomerules enter this plexus.

The arterial branches of the medullary substance descend between and parallel with the straight tubes (to form the *arteriolæ rectæ*), and anastomose by transverse branches, so as to form a network with elongated meshes (around and between the tubuli).

The (*renal* vein) issues from the kidney by the hilus, and succeeds the arterial

Fig. 341.

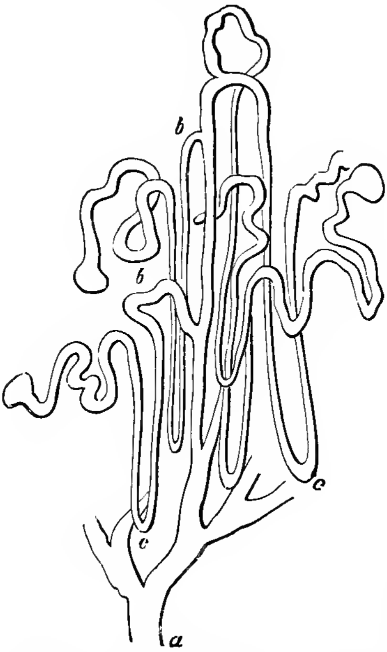
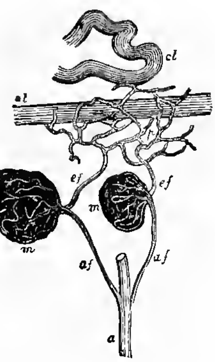


DIAGRAM OF THE COURSE OF THE URINIFEROUS TUBULE.

a, Orifice of tubule at pelvic crest; *b*, recurrent branches which form loops, *c*, in the medullary portion of the kidney, and terminate in the Malpighian capsules in the cortical portion.

Fig. 342.



DISTRIBUTION OF THE RENAL VESSELS IN THE HORSE'S KIDNEY.

a, Branch of renal artery; *af*, afferent vessel; *m*, *m*, malpighian tufts; *ef*, *ef*, efferent vessels; *p*, vascular plexus surrounding the tubes ; *st*, straight tube; *ct*, convoluted tube.

capillaries. In the medullary substance, there are straight veins as there are straight arteries. On the surface of the organ, beneath the fibrous envelope, are the *stellate veins of Verheyen*—the junction of five or six venules which converge towards a central vein. The venules of the two portions collect into more voluminous vessels, which form complete arches at their limits; it is to the presence of these vascular canals that the dark colour observed at this point of the renal tissue must be attributed.

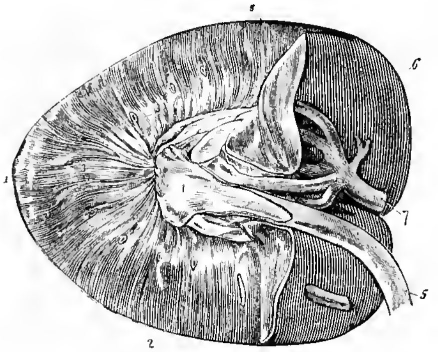
b. The *lymphatics* are abundant in the mass, but rare at the superficies of the organ ; they form plexuses, the ultimate branches of which pass to the sublumbar glands.

c. The *nerves* emanate from the *solar plexus*, and form a particular network around the arteries, exhibiting, on their course, some microscopic ganglia. It is not known how they terminate.

Development.—The kidneys appear very early in the fœtus, above and a little behind the Wolffian bodies. They are then very distinctly lobulated, but the lobes gradually become fused, and have entirely disappeared at birth; the small irregularities on the surface are the only indications of their ever having existed in Solipeds.

Functions.—The kidneys are the organs which secrete the urine; but this secretion does not take place to the same extent in all parts of their tissue. The abundance of vessels in the cortical substance, the presence of the Malpighian corpuscles, and the flexuosities described by the uriniferous tubes, sufficiently indicate that this substance should be the principal, if not the exclusive, seat of the secretory function. But in what manner does this secretion take place? At present it is generally agreed that the urinary secretion is simply an infiltration of the elements of the urine contained in the blood, through the walls of the vessels of the glomerulus. The difference existing between the diameter of the afferent and efferent vessels of the Malpighian glomerules—a fact the importance of which was pointed out by Ludwig—sufficiently explains this filtration of the urine through the tissue of the kidneys.

Fig. 343.



TRANSVERSE SECTION OF THE KIDNEY.

1, Inferior border; 2, cortical tissue; 3, section of blood-vessels; 4, pelvis; 5, ureter; 6, superior border; 7, renal artery; 8, proper capsule.

The nutritive principles of the serum which leave the blood at the same time as those of the urine, are taken up by the epithelium of the uriniferous tubes.

2. The Ureters (Fig. 338).

Form.—The *ureter* is a membranous canal, the diameter of a thick goose-quill, which conveys the urine from the pelvis of the kidney into the bladder. Its origin, course, termination, and structure, will be successively considered.

Origin.—It has been already shown that the origin of the ureter is at the infundibulum of the pelvis of the kidney; it leaves that organ by the internal fissure or hilus, curves outwards, passes along its lower face, and is inflected backwards in quitting the organ.

Direction.—The course it follows is almost in a straight line towards the pelvic cavity, along with the posterior aorta or posterior vena cava, according to the side to which it belongs; it is in contact with the psoas parvus, and proceeds above the peritoneum. After passing beyond the terminal branches of the posterior aorta, which it crosses very obliquely, it becomes enveloped in a short peritoneal fold that maintains it against the lateral wall of the pelvis; it afterwards emerges from this fold, and reaches the posterior and superior part of the bladder.

Termination.—Having reached that viscus, its termination takes place as follows: instead of opening directly into the bladder by traversing at once, and perpendicularly, the two membranes composing the organ, the ureter at first pierces the muscular coat, between which and the mucous membrane it passes for about an inch, and then opens on the surface of the latter. This arrangement prevents the flowing back of the urine into the ureter during its expulsion, the intermembranous portion of that canal being strongly compressed by the external pressure then exerted by the muscular coat, and by the internal resistance which the accumulation of urine in the bladder opposes to this pressure. So well are Nature's intentions fulfilled in this respect, that we may inflate the bladder by the ureter, after tying the canal of the urethra, and press vigorously on the distended organ, without being able to make a single bubble of air pass through the perfectly pervious canal.

STRUCTURE.—The excretory canal of the kidney is composed of three tunics :

1. An internal *mucous* tunic, continuous, in front, with that lining the pelvis of the kidney, and behind, with that of the bladder. It is very thin, pale, plicated longitudinally, and has a stratified tesselated epithelium. (It has some mucous follicles, but no villi.)

2. A middle *muscular* layer arranged in two orders—a superficial, the fibres of which are circular, and a deep set, passing in a longitudinal direction. (Leyh and other authorities describe the arrangement of the muscular planes—which are composed of smooth fibres—to be the reverse of this, the longitudinal being superficial, and the deep circular.)

3. An external tunic, composed of connective tissue and elastic fibres.

The muscular tissue of the ureter, by contracting, accelerates the flow of the urine.

3. THE BLADDER (Fig. 338).

Position.—This is a membranous reservoir, lodged in the pelvic cavity, where it occupies more or less space, according to the quantity of urine it contains ; it may extend beyond the pubis, into the abdominal cavity.

Form.—Considered in a moderate state of plentitude, the bladder is ovoid in figure ; its large extremity, being turned forward, forms a rounded *cul-de-sac* (*fundus*), at the bottom of which is remarked a kind of cicatrice, caused by the obliteration of the urachus. The other extremity terminates, posteriorly, by a well-marked constriction—*the neck* (or *cervix*) *of the bladder*—which gives rise to the urethral canal.

Weight.—The average weight of the empty bladder is about sixteen ounces.

Relations and mode of attachment.—The bladder is related : above, to the vesiculæ seminales, to the pelvic dilatations of the vasa deferentia, as well as to the rectum ; below, to the inferior wall of the pelvis, on which it rests (by its *base*) ; on the sides, to the lateral walls of that cavity. In the female, the upper face of the bladder is in relation with the uterus and vagina, which entirely separate it from the rectum. The posterior extremity or *neck* (*cervix*), flanked on each side by the lobes of the prostate, is fixed below to the ischio-pubic symphysis, by means of a particular ligament or fasciculus of elastic and contractile fibres, which are detached from the muscular layer, and expanded over the lower face of Wilson's muscle, to be carried backwards and downwards, and terminate on the surface of the internal obturator muscle. The anterior extremity—or *fundus*—is usually related to the pelvic flexure of the large colon.

This extremity is covered by a serous cap, which is prolonged backwards on its body, further above than below. This covering is continuous with the parietal layer of peritoneum, and adheres closely to the muscular tunic of the bladder, so that it constitutes its chief attachment ; its arrangement is precisely similar, in principle, to that of the other serous visceral membranes.

Thus the peritoneum, after covering the walls of the pelvis, is reflected on the organs contained in that cavity, and in particular on the bladder, around which it forms an orbicular fold. This again gives rise to three secondary folds—a kind of serous layers—which are usually termed the *ligaments of the bladder*. One of these layers is single and vertical (*broad ligament*), and is fixed to the inferior part of the fundus ; it is not rare to see it prolonged forward on the lower wall of the abdomen, as far as the umbilicus ; on its free border it is said to have a thin hem or cord—the last vestige of the urachus. If this cord exists—which appears doubtful to us—it cannot possess the signification given to it ; for the urachus has not, like the umbilical arteries, an abdominal portion ; it only commences at the umbilicus to be prolonged in the cord to the allantois. The other two serous layers (*umbilical ligaments*)—pairs and horizontal—are attached to the sides of the fundus, and present, on their free border, a thick cord, the obliterated umbilical artery.

(These are the so-called *false ligaments*. There are *true ligaments*, formed by processes of the pelvic fascia, which, in the male, are : the *inferior*, attaching the prostate gland to the bladder ; the *lateral*, attached to the sides ; and a *recto-vesical*, between the bladder and rectum. In the female, there are the *vesico-uterine* and *recto-uterine* ligaments.)

Owing to this disposition of the peritoneum, the bladder is divided into two perfectly distinct regions : an anterior, enveloped by a serous layer ; the other, posterior, is brought in contact with the surrounding organs through the medium of the loose and abundant connective tissue of the pelvic region. This tissue—constantly mixed with adipose masses around the neck of the bladder—submits, with the serous membrane of the anterior region, to the changes in form and continual displacements of the urinary sac.

Interior.—This pouch, studied internally, exhibits folds and ridges more or less marked, according to its state of plenitude. It also shows, posteriorly, the opening of the neck, which communicates with the urethral canal, and a little higher, the orifices of the ureters. These three apertures circumscribe a smooth triangular space—the *trigone* (*trigonum vesicæ*).

STRUCTURE.—The structure of the bladder is very simple. Two membranes compose its walls, the internal of which is mucous, and the external muscular. Anteriorly, the latter is covered by the peritoneum described above.

The *mucous membrane* is pale and thin, and is continuous with that lining the ureters and the urethra. It shows some papillæ and some simple tubular glands towards the neck. Its epithelium is stratified and tesselated, the superficial cells being very irregular.

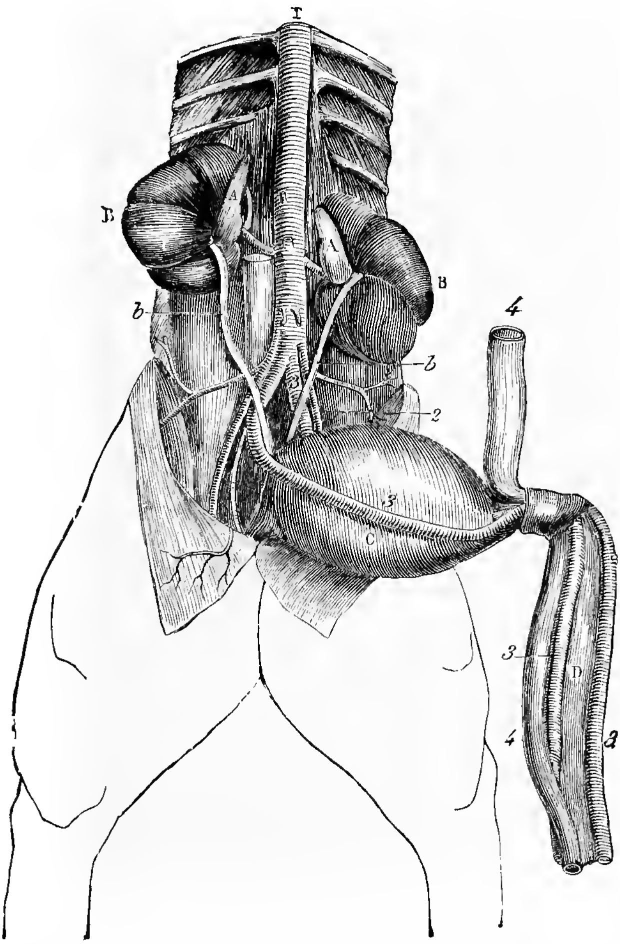
The *muscular layer* is composed of white fibres, the arrangement of which is very complicated. Certain authorities describe three superposed planes, the fibres of which pass in different directions. In the Horse, in which the walls of the bladder are very thin, these planes are difficult to demonstrate. The fibres are longitudinal, circular, oblique, spiral, and even twisted towards the fundus of the bladder ; the deep fibres are reticulated. In the posterior region they do not form a sphincter around the neck of the organ, as is generally believed ; the real sphincter is Wilson's muscle, which encircles the membranous portion of the urethral canal.

(A *submucous layer*, composed of vascularized connective tissue, has been described ; it loosely connects the mucous and muscular layers.)

Vessels and nerves.—The parietes of the bladder receive their blood from several sources. The principal *arteries* come from the vesico-prostatic branch of the internal pudic; the umbilical artery also furnishes ramifications that reach the fundus of the organ. The *lymphatics* pass to the sublumbar glands. The *nerves* are furnished by the pelvic or hypogastric plexus, and the inferior branches of the two last sacral pairs; their twigs are spread more especially between the muscular and mucous layers.

DEVELOPMENT.—The study of the development of the bladder is very interest-

Fig. 344.



THE KIDNEYS AND BLADDER IN THE FŒTUS OF SOLIPEDS.

A, Supra-renal capsules; B, kidney; *b*, ureter; C, bladder; D, urachus. 1, abdominal aorta; 2, external iliac artery; 3, umbilical artery; 4, umbilical vein.

ing. It is narrower and more elongated in the fœtus than the adult, and is relatively more capacious during the whole period of intra-uterine life. It then occupies the abdominal cavity as far as the umbilical opening, and is flanked by the two umbilical arteries. Its posterior extremity alone enters the pelvis; the anterior extremity, forming a real neck, is continuous with the urachus, just as the neck, properly so called, is continuous with the urethra (Fig. 344). At birth, this anterior neck separates from the urachus, and is transformed into a free *cul-de-sac;* while the bladder is gradually withdrawn into the pelvic cavity, carrying with it the umbilical arteries, and finishes by acquiring the position it definitively occupies in the adult.

FUNCTIONS.—The part played by the bladder is of incontestible utility. In permitting the accumulation of the urine and the intermittent expulsion of that excrementitial fluid, it spares animals the disagreeable condition in which they would be placed if the liquid secreted by the kidneys was continually being discharged as produced.

4. URETHRA.

The description of this organ will be given with that of the genital organs, as in the male it is common to the urinary and generative apparatus; even in the female it is intimately connected with the latter.

5. THE SUPRA-RENAL CAPSULES (Fig. 338, 344).

Situation—Form.—The *supra-renal capsules* (or *adrenals*) are two small bodies applied to the lower face of the kidneys, in front of the hilus, and close to their inner border.

They are elongated from before to behind, flattened above and below, and irregularly lobulated on their surface. Their length is from 2 to $2\frac{1}{3}$ inches, and width from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. They have not the same volume, the right being larger than the left.

Relations.—A large amount of connective tissue, vessels, and nerve-filaments attach these bodies to the neighbouring organs. The right is related, in front, to the liver; above, to the right kidney; and inwardly, to the posterior vena cava and the ramifications of the solar plexus. The left does not touch the liver or spleen, but, by its inner border, is applied against the posterior aorta and great mesenteric artery.

STRUCTURE.—At present, anatomists are not agreed as to the structure of the supra-renal capsules. The following is what is probably most reliable in this difficult point in normal histology.

These organs offer an enveloping membrane and parenchyma.

The *enveloping membrane* is *fibrous*, and sends off, from its inner face, prolongations which pass into the parenchyma and form cylindrical spaces, subdivided by transverse bands. These spaces are named glandular cavities; but the septa soon become thin, and disappear almost completely, leaving nothing but some very few trabeculæ of connective tissue.

The *parenchyma* is divisible into two layers—the *cortical* and the *medullary substance.* The first is of a dark-brown colour; the second is yellow and soft, and does not show any cavity in its centre; that which has been described is the result of the destruction of its proper elements, which soon change after death.

The glandular cavities of the *cortical substance* are filled with nucleated, granular, and often fat cells, in the adult animal; near the central substance these cavities only contain a single cell.

The *medullary substance* has, for its basis, a very delicate reticulum, supporting stellate cells analogous to those of nerve-tissue.

Vessels and nerves.—Like the kidneys, which are contiguous, the supra-renal capsules receive a large quantity of blood, compared with their small volume. The *arteries* are branches of the neighbouring vessels—the mesenteric and renal. They form a very delicate plexus in the parenchyma. (They keep to the stroma of the trabeculæ ; consequently, their finest ramifications are found in the secondary septa of the cortical substance, where they form elongated plexuses, which are rounder in the medullary portion. In the middle of the latter, the venous ramuscules unite, and give rise to a considerable trunk—the *vena supra-renalis*—on which the organ is placed as on a pedicle. It is this vein which constitutes the debated cavity.)

The *veins* are satellites of the arteries in the tissue of the organ, and pass into the renal vein or posterior vena cava. The *lymphatics* are scarce.

The supra-renal bodies receive many *ganglionic nerves* derived from the solar plexus, but their mode of termination is unknown. (As mentioned by Chauveau, the nerves of these organs are extremely numerous, they being more abundantly supplied than any other structure of the kind in the body ; a large number of small branches enter the cortical portion, to become developed in the medullary tissue. As these nerves do not leave the medullary substance, and as, besides, its cellular elements appear to be of the same nature as the multipolar ganglionic cells, it is presumed that the nerve-fibres emerge from these globules, and that the medulla acts as a ganglionic nerve centre. Though Leydig fully believed the internal portion to be of a nervous character, he thought another function might be attributed to the cortical, in consequence of its being most frequently of a fatty nature. Bergmann was the first, in 1839, to class these organs with the nervous system, and Remak, in 1847, by his researches in embryology, was led to group them with the sympathetic ganglia, and named them *nerve-glands*. Injury to the dorsal portion of the spinal cord, causes congestion and hypertrophy of the supra-renal capsules. In a watery solution of the cortical portion, a rose-tinted substance has been discovered, which changes to green with persalts of iron.)

Development.—These bodies are relatively larger in the fœtus than the adult, though this difference does not influence their structure.

(Functions.—Their uses are still unknown ; they are ranked in the category of blood-vascular glands, along with the spleen and thyroid body, the functions of which are also not yet ascertained. Leydig is of opinion that these bodies should be regarded as belonging to the nervous system ; but it is probable that they are concerned in the processes connected with pigmentation.)

Differential Characters in the Urinary Apparatus of the other Animals.

1. *Kidneys.*—In the other domesticated Mammals, the renal glands are simple or multiple, or, in other words, simple or lobulated. In the **Ox**, the kidneys have an elongated shape from before to behind, which is altogether characteristic; and, in addition, they preserve during life the lobulated form only seen in the other animals during intra-uterine existence. Each agglomeration is composed of from fifteen to twenty secondary kidneys; but the pelvis is not formed in the centre of this agglomeration, being carried altogether outwards, and occupying an excavation in the interior face of the organ, which represents the hilus. This cavity is divided into as many short, wide prolongations—the *calices*—as there are principal lobules; the uriniferous tubes from each lobule open on a small papilla, which projects into the bottom of the calyx. This papilla is, therefore, nothing more than the crest of the simple pelvis in the kidney of Solipeds (Fig. 347).

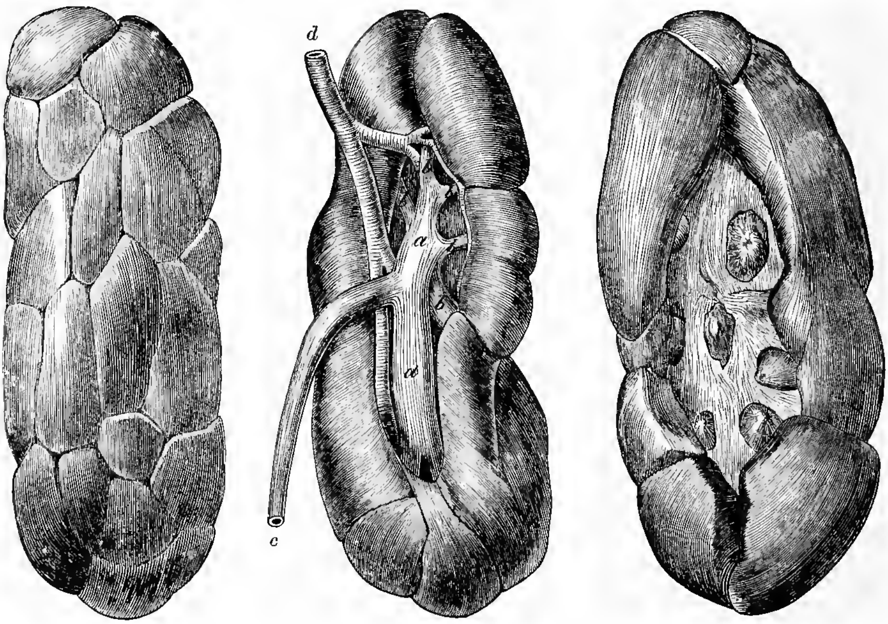
In the **Sheep** and **Camel**, the kidneys are not lobulated, and the pelvis is carried to the inner border, as in the Horse. In these animals, as well as in the **Dog** and **Cat**, there is an arrangement which establishes a kind of transition between the pelvis of the Ox and that of

Solipeds. In them, this cavity is very large, and at the base of the crest shows deep diverticuli that ramify in the substance of the kidney.

The kidneys of the **Pig** are simple externally, and voluminous; the hilus gives access to a cavity in which are a number of papillæ collected in twos or threes, and covered by calices. The calices and the ureter have the same arrangement as in the Ox. (There are 10 or 12 papillæ, and as many calices.)

2. *Bladder.*—The most important difference in the bladder of the domesticated animals, consists in the extent of development of its peritoneal envelope. In nonsoliped animals this covers all the organ to the neck; the ligaments are also very short, and the viscus may be easily projected into the abdominal cavity. The bladder is thin, and of considerable capacity in **Ruminants** and the **Pig**; in the **Dog**, on the contrary, it has a very thick muscular layer, its fibres forming distinct fasciculi, especially when in a state of retraction. (In **Ruminants**, the orifices of the ureters are near each other; at the fundus the mucous membrane shows a small fossa, which is continued by a narrow canal that terminates in a

Fig. 345. Fig. 346. Fig. 347.



KIDNEYS OF THE OX.

Fig. 345.—Right kidney, viewed on its upper and external face. Fig. 346.—Left kidney, from its internal and inferior face: *a*, Pelvis; *b*, *b*, *b*, branches of the pelvis terminating in calices; *c*, ureter; *d*, renal artery. Fig. 347.—The calices in the left kidney. The contents of the hilus, including the branches of the pelvis, have been removed to show the tubercles at the bottom of these calices. Only seven are visible, the others being beneath the borders of the renal fissure.

cul-de-sac, and constitutes a free appendix about half an inch long, and of the thickness of a goose-quill).

3. *Supra-renal capsules.*—These small organs are discoid in the **Sheep** and **Pig**, reniform in the **Dog**. In the **Ox**, they are situated at a certain distance in front of the kidneys, and their shape is like that of these bodies in the Horse; though they are a little constricted in the middle, and slightly curved.

In **Birds**, the kidneys "are lodged at the same height, behind the peritoneum, immediately posterior to the lungs, and in the lumbar and pelvic regions, where they occupy several fossæ excavated in the upper face of the pelvis. Their form is irregular and more or less elongated, depending upon the bones and other parts to which they are applied, and on which they are moulded. In many Birds, nevertheless, three portions, more or less separated by fissures, may be recognized. The ileo-lumbar portion—so named because of its constant position in this region—is the most advanced; it is often the largest. The middle is the narrowest; it is turned towards the ileo-sacral region, to enter the pelvis. The posterior is contained in that cavity, and is again larger. These two latter portions are designated as the anterior or superior pelvic, and the inferior or deep pelvic portions. Their internal and superior border is often notched by a series of transverse fissures, produced by the protrusion of the transverse processes of the sacral vertebræ, as the lungs are furrowed by the projection of the ribs."[1]

The excretory apparatus is incomplete, and is only formed by the ureters, which open into the cloaca, where the urine is mixed with the fæces. Only [illegible] Ostrich—possesses a bladder, which is disposed in a particular manner.

Comparison of the Urinary Apparatus of Man with the [illegible] Animals.

1. *Kidneys.*—The two kidneys of Man have, like those of the smaller domesticated animals, the same shape—that of a haricot bean. The average weight is about from three to five ounces. Contrary to what is observed in the Horse, the left kidney is more voluminous than the right, and is higher.

The kidneys are simple externally, though their tissue is disposed in distinct lobes, which number from eight to fifteen, and each is composed of a Malpighian pyramid and a superposed pyramid of Ferrein; they terminate, towards the hilus, by a cone or renal papilla, each surrounded by a calyx, and are separated by small prolongations of the cortical substance—the *columnæ Bertini.*

2. *Ureters.*—These canals are disposed at their origin as in the Ox: they terminate as in the other animals. In the hilus of the kidney are from eight to fifteen prolongations or *calices,* which unite into a larger cavity or *great calyx,* that finally opens into the renal pelvis; this is immediately followed by the ureter.

3. *Bladder.*—The large extremity of this organ is directed downwards in the bottom of the pelvis, where it is continuous with the urethral canal; its summit is directed upwards, and is frequently pointed. Its mode of attachment and internal conformation are the same as in animals; and, as in the Horse, the peritoneum envelops it very incompletely. The muscular fibres are arranged in three planes—a superficial, which forms a band that is carried from the anterior to the posterior face in passing over the summit; a middle plane, the fibres of which are circular; and a deep plane with reticulated fibres.

Supra-renal capsules.—This name is quite appropriate to these bodies, as in Man—or at least in the fœtus—they form a kind of helmet that covers the upper part of the kidney.

There is nothing to add respecting their structure.

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[1] Cuvier, *Anatomie Comparée*, 2nd Edition. Paris: 1836–46.

BOOK V.

CIRCULATORY APPARATUS.

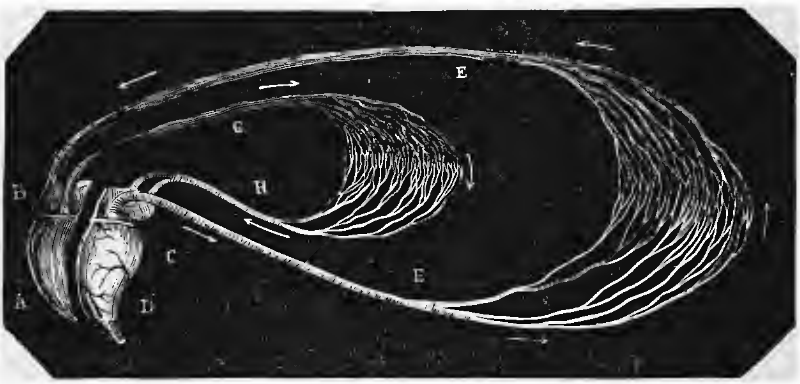
THE animal economy is incessantly traversed by two fluids—*blood* and *lymph.*

The *blood* is a fluid, coloured bright red or brown by particular globules, and from which the tissues derive not only the materials for nutrition and secretion, but also the exciting principle which vivifies the organic matter. It is named *red* or *arterial*, and *dark-coloured* or *venous* blood, according to its tint.

The *lymph*, or *white blood*, is a transparent, citrine-coloured fluid, which can be obtained from most of the organs. That which comes from the abdominal portion of the alimentary canal is charged, during digestion, with a portion of the reparative materials elaborated in that apparatus, and is distinguished by its lactescent aspect; it is designated the *chylé.*

These fluids are carried by *vessels*—tubes continuous with one another. When joined together, end to end, these tubes give rise to three principal canals:

Fig. 348.



THEORETICAL PLAN OF THE CIRCULATORY SYSTEM.

(H D C E, The canal for red blood; E B A G, canal for dark blood. The arrows indicate the course of the blood. The two canals are represented in their middle portion, A B, C D, as isolated; but in nature they are enveloped at this point in a common sac that concurs to form the heart.)

"One of these canals extend from the lungs to all parts of the body, and is traversed by red blood.

"The second extends from all parts of the body to the lungs, and carries dark blood.

"The third passes from the majority of the organs towards the canal carrying dark blood, in which it terminates; it conveys the white blood, or lymph.

"The *red-blood* and *dark-blood canals* bear the greatest analogy to each other.

Both are simple in their middle portion, which alternately dilates and contracts to impress upon the blood the movement necessary to life. Both present at their extremities innumerable ramifications, which ultimately join each other ; so that the fluid they carry passes from one to the other in a constant and circular direction. Both are composed, at their origin, of vessels in which the blood moves in confluent columns—*these are the veins ;* and in their terminal portion, of vessels in which the same fluid is spread in divergent columns—*these are the arteries* (Fig. 349).

"The *canal for white blood* is composed of a single order of vessels—the *lymphatics*—converging tubes, the common trunk of which opens into the circulatory canal resulting from the junction of the red and dark blood vessels ; the relation it affects with these latter, is that of a tangent with its circumference." (Sappey.)

These three canals constitute the *circulatory apparatus.*

This apparatus therefore comprises : 1. The *heart,* a central organ, which propels the blood. 2. A system of centrifugal vessels—the *arteries*—which carry the blood from the heart into the different organs. 3. A system of centripetal vessels—the *veins*—which bring the nutritive fluid to the heart. 4. The *lymphatics*, an accessory centripetal system, for conveyance of lymph into the blood-vascular circle.

In many anatomical works, the study of this apparatus—the heart, arteries, veins, aud lymphatics—is designated *Angiology.*

FIRST SECTION.

THE HEART.

The history of the heart comprises : 1. A general view of the organ. 2. The study of its external conformation. 3. Its interior. 4. Its structure. 5. A description of the pericardium, the serous cavity containing it. 6. A glance at its physiology.

1. The Heart as a Whole (Figs. 255, 349, 350).

General sketch.—The heart—the central portion of the circulatory apparatus—is a hollow muscle, the cavity of which is divided by a thick vertical septum, into two perfectly independent chambers. Of these two contractile cavities, one—placed on the track of the dark blood—propels it into the lungs ; the other—situated on the course of the red blood—distributes it to all parts of the body.

Each of these is subdivided into two superposed compartments by a circular constriction, at which is a membranous valve that, at certain fixed periods, is elevated, and then forms a comple horizontal partition extended between the two compartments.

The superior compartment receives the convergent or centripetal portion of the blood-canal—that is the veins : it is named the *auricle.* The inferior gives origin to the divergent or centrifugal part of the same canal, and is designated the *ventricle.*

The cavities of the heart are distinguished into *right* or *anterior*, and *left* or *posterior*, because of their relative positions. There are, then : a *right auricle* and *ventricle*—the two dark-blood cavities ; and a *left auricle* and *ventricle*, situated on the track of the red-blood canal.

Situation.—The heart is enclosed in a fibro-serous sac, named the *pericardium*, and is placed in the chest between the two layers of the mediastinum, opposite the third, fourth, fifth, and sixth ribs ; in front of the diaphragm, which separates it from the abdominal viscera ; above the sternum, which appears to support it ; and beneath the vertebral column, to which it is suspended by means of the large vessels. (Between the middle of the anterior border of the heart, in front, and the entrance to the chest, is an interval of about four inches ; and behind, at the same level, this organ is at a similar distance from the diaphragm. It is distant from the fifth and sixth dorsal vertebræ—from which it is suspended —about $4\frac{1}{2}$ or 5 inches in an average-sized Horse.)

Form and direction.—The heart presents the form of an inverted cone, slightly depressed on each side, the axis of which, directed obliquely downwards and backwards, deviates a little to the right at its superior extremity.

Volume.—In a medium-sized Horse, the greater axis of the heart is about $10\frac{1}{4}$ inches in length ; its antero-posterior diameter, measured near the base, is equivalent to about $7\frac{1}{2}$ inches. Its lateral diameter does not exceed from 5 to $5\frac{1}{2}$ inches.

Capacity.—It is very difficult, if not impossible, to obtain the exact capacity of the heart's cavities. From reasoning, it might be supposed that the two hearts have exactly the same capacity, and that this is equivalent to an average of from 1 to $1\frac{1}{4}$ pints. The amount obtained by measurement is much more considerable ; but then the heart is distended to a greater extent than in its physiological state.

Weight.—The weight of the heart varies with the size of the animals, and that to a considerable degree. Its average is about $6\frac{3}{4}$ pounds. (The volume and weight of the heart are very much greater in well-bred than in common-bred Horses. Its dimensions and capacity are greater in the living than the dead animal ; as after death its cavities contract, particularly the aortic ventricle, which has the thickest walls. This ventricle will then scarcely contain more than from $\frac{3}{4}$ to $1\frac{1}{4}$ gills ; the pulmonary ventricle, which is not so thick, and consequently less contracted, may usually receive double that quantity ; while in animals experimented on when expiring, it has been observed that these two ventricles were much more capacious, and that each contained at least from $1\frac{1}{4}$ to $1\frac{1}{2}$ pints.)

2. External Conformation of the Heart (Figs. 349, 350).

Preparation.—Remove the heart, and with it a certain length of the vessels belonging to it; fill its cavities with tow, and free the furrows from the adipose deposited in them.

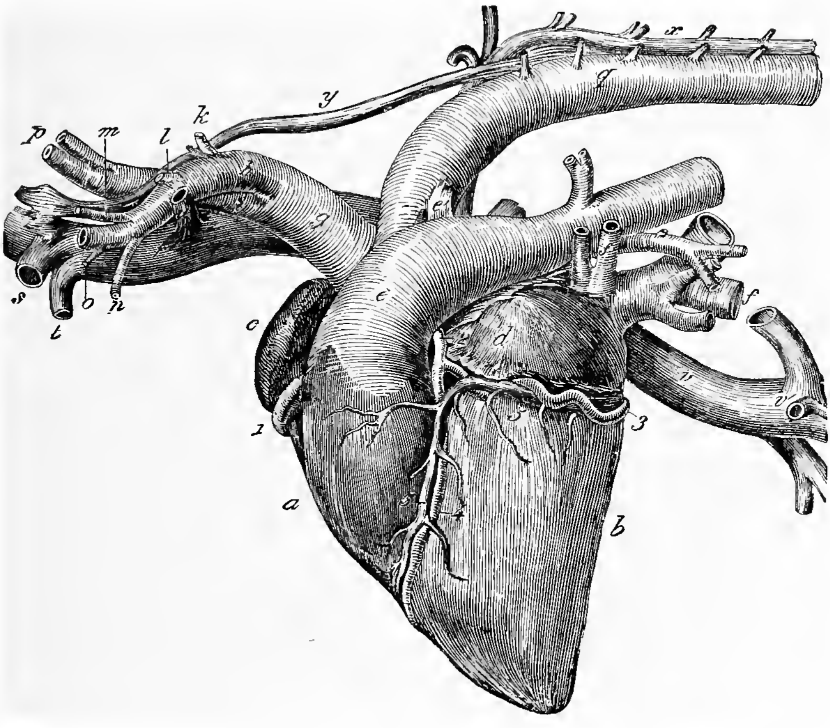
The cone represented by the heart is divided by a horizontal groove into two unequal portions : the one superior, comprising the *auricles* or *auricular mass* ; the other inferior or principal, formed by the *ventricles* or *ventricular mass*.

A. **Ventricular Mass.**—It is this which determines the conical shape of the heart, and constitutes its largest portion. Owing to a slight flattening of the organ in a lateral sense, it may be considered as having a *right* and *left face*, an *anterior* and *posterior border*, an *apex*, and a *base*.

The *right face*, smooth and rounded, is traversed by a vascular furrow (*right* *ventricular groove*) parallel to the axis of the heart, and which divides this face into two sections—an anterior, belonging to the right ventricle; and a posterior, less extensive, forming part of the left ventricle (Fig. 350).

The *left face*, disposed in the same manner, also shows a groove (*left ventricular groove*) on the limit of the two ventricles, which slightly crosses the large diameter of the heart from behind to before, and above to below, and is much nearer the anterior than the posterior border (Fig. 349).

Fig. 349.



THE HEART AND PRINCIPAL VESSELS (LEFT FACE).

a, Right ventricle; *b*, left ventricle; *c*, right auricle; *d*, left auricle; *e*, pulmonary artery; *e'*, obliterated ductus arteriosus; *f*, pulmonary veins; *g*, anterior aorta; *h*, left axillary artery; *i*, right axillary artery, or brachio-cephalic trunk; *j*, origin of the dorsal artery; *k*, origin of the superior cervical artery; *l*, origin of the vertebral artery; *m*, origin of the inferior cervical artery; *n*, origin of the internal thoracic artery; *o*, origin of the external ditto; *p*, carotid arteries; *q*, posterior aorta; *r*, anterior vena cava; *s*, trunk of the axillary vein; *t*, trunk of the internal thoracic vein; *u*, trunk of the dorso-cervical vein; *v*, posterior vena cava; *v'*, junction of the hepatic and diaphragmatic veins; *x*, vena azygos; *y*, thoracic duct; *z*, embouchure of that vessel, placed near the origin of the anterior vena cava. 1, Right cardiac artery; 2, left cardiac artery; 3, auriculo-ventricular branch of the latter; 4, its ventricular branch; 5, cardiac vein.

These two faces are related, through the medium of the pericardium, to the pluræ and pulmonary lobes; the latter separate them from the thorax, except towards the middle and apex of the organ, where these faces come directly in contact with the thoracic parietes through the notch at the inferior border of the lung, and which is more marked in the left than in the right.

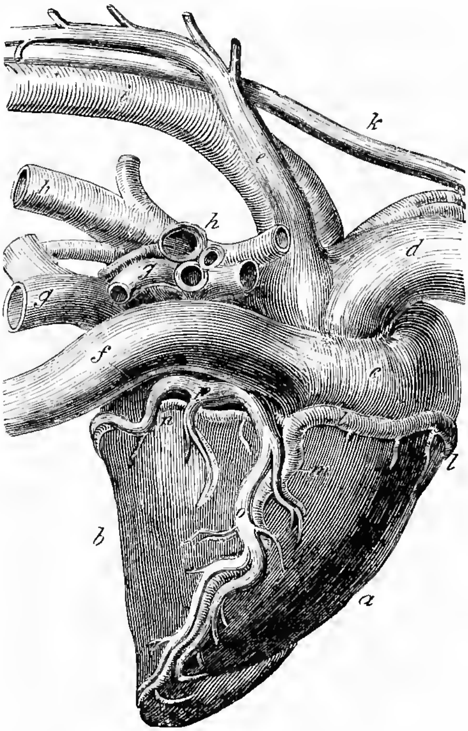
The *borders* are thick, smooth, and rounded. The *anterior*, formed by the right ventricle, is very oblique downwards and backwards; it inclines on the sternum more or less, according to subjects.

The *posterior border*, much shorter than the anterior, is nearly vertical. Superiorly, it is separated from the diaphragm by the lung; but, below, it is quite close to that muscular septum.

The *apex*, or point of the ventricular cone, is blunt, slightly rounded, turned to the left, and formed entirely by the left ventricle.

The *base* is related on the right, in front, and behind, to the auricles; it gives off on the left, and a little in front, the two arterial aortic and pulmonary vessels.

Fig. 350.



THE HEART AND PRINCIPAL VESSELS (RIGHT FACE).

a, Right ventricle; *b*, left ventricle; *c*, right auricle; *d*, anterior vena cava; *e*, vena azygos; *f*, posterior vena cava; *g*, *g*, pulmonary veins; *h*, *h*, divisions of the pulmonary artery; *i*, posterior aorta; *j*, anterior aorta; *k*, thoracic duct; *l*, right cardiac artery; *m*, its vertical or ventricular branch; *n*, its horizontal or auriculo-ventricular branch; *o*, ventricular branch of the cardiac vein; *p*, auriculo-ventricular branch of the same.

B. **Auricular Mass.**—Elongated from before to behind, disposed like a crescent above the right side of the base of the ventricles, constricted in its middle part, on the limit of the two auricles, the auricular mass presents for study *three faces*, *two extremities*, and *a base*.

The *superior face* is divided by a middle constriction into two convex sections, each of which corresponds to an auricle. The anterior—or right section—shows the entrance of the anterior vena cava and vena azygos; the posterior—or left section—that of the pulmonary veins. The trachea, bronchi, and pulmonary artery pass above this face (Figs. 349, 350).

The *right face*, the most extensive in the anteo-posterior direction, is divided like the preceding, and disposed in a similar manner. The right, or anterior part, receives—behind and below—the insertion of the posterior vena cava, and the coronary and bronchial veins (Fig. 350).

The *left face*, concave from before to behind, includes the arterial trunks which leave the base of the heart.

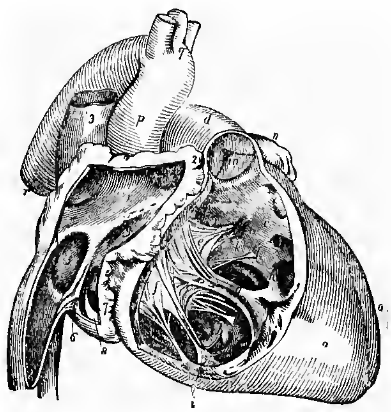
Each of the extremities—*anterior* and *posterior*—constitutes a detached portion, named the *appendix auricularis;* these appendages are curved towards each other in being flattened above and below. Their convex border is more or less crenelated, like the margin of a cock's comb, and their culminating portion advances nearly to the pulmonary artery, above the trunk of the cardiac vessels (Fig. 349).

The *base* of the auricular mass, opposed to the base of the ventricles, is separated from it at its periphery by the horizontal groove (*auriculo-ventricular groove*) of the heart.

3. Internal Conformation of the Heart (Figs. 351, 352, 353).

Preparation.—It suffices to make a longitudinal incision before and behind the organ, in order to expose its cavities. (I have followed Wilson's directions for many years when examining the interior of the heart, and as a careful inspection of this organ is often necessary in the course of an autopsy, I think the student should practise the best method of laying open these cavities. The right auricle is prepared by making a transverse incision along its ventricular margin, from the appendix to its right border, and crossed by a perpendicular incision, carried from the side of the anterior to the posterior cava. The right ventricle is laid open by making an incision parallel with, and a little to the right of, the middle line, from the pulmonary artery in front, to the apex of the heart, and thence by the side of the middle line behind to the auriculo-ventricular opening. The interior of the left auricle is exposed by a ⊥-shaped incision, the horizontal section being made along the border which is attached to the base of the ventricle. The latter is opened by making an incision a little to the left of the septum ventriculorum, and continuing it around the apex of the heart to the auriculo-ventricular opening behind.)

Fig. 351.



RIGHT SIDE OF THE HEART LAID OPEN.

1, Cavity of right auricle; 2, appendix auriculæ, with musculi pectinati; 3, anterior vena cava opening into the upper part of the right auricle; 4, posterior vena cava; 5, fossa ovalis, surrounded by the annulus ovalis; 6, Eustachian valve; 7, opening of the coronary sinus; 8, coronary valve; 9, entrance of auricular-ventricular opening. *a*, Right ventricle; *b*, its cavity; c, conus arteriosus, or infundibulum; *d*, pulmonary artery; *e*, *f*, tricuspid valve; *g*, one of the musculi papillares to which the curtains of the tricuspid valve are attached by chordæ tendinæ; *h*, columnæ carneæ; *i*, two musculi papillares of valvular curtain; *l*, *l*, chordæ tendineæ; *m*, semilunar valves of pulmonary artery; *n*, apex of left appendix auriculæ; *o*, left ventricle.

If the heart, when viewed externally, appears to be a simple organ, it is not so when examined internally. The vertical septum which divides it into two bilocular cavities, in reality makes two hearts of it—one for the dark, the other for the red blood. We will successively study these two cavities, by commencing with the partition that separates them.

A. Cardiac Septum.—The superior part of this septum, between the two auricles, is named the *inter-auricular partition* (*septum auricularum*). The inferior portion constitutes the *inter-ventricular partition* (*septum ventriculorum*). The first—thin and not extensive—is perforated in the fœtus by the *foramen of Botal* (*foramen ovale*). The second, thick in its centre, thins a little towards its borders.

B. Dark-blood (or Pulmonary) Heart.—The two superposed cavities forming this portion are situated in front and to the right. They are indifferently named the *anterior* or *right cavities* of the heart—the latter term being in general use, though the first is much more convenient in Veterinary Anatomy.

Right Ventricle.—The right ventricle represents a hollow cone, a horizontal section of which resembles a crescent, its posterior plane being pushed into the cavity by the left ventricle.

It offers *two walls*, *an apex*, and *a base*.

Walls.—The *anterior wall* is concave; its thickness is more considerable above than below, and averages $\frac{6}{10}$ of an inch. The *posterior wall* is convex, and formed by the septum ventriculorum.

Both walls are uneven, from the presence of fleshy columns (*columnæ carneæ*), which we will commence examining in a general manner, as they are found in the four compartments of the heart. They are of three kinds: one kind, named the *pillars of the heart* (*musculi papillares*)—thick and short, and fixed by their base to the walls of the ventricles—have a free summit, into which are implanted the tendinous cords (*chordæ tendinæ*) proceeding from the auriculo-ventricular valve; those of the second order (*trabeculæ carnæ*) are free in their middle part, and attached by their extremities to the walls of the heart; while the third description (*columnæ*) adhere throughout their length to the cardiac tissue, on which they stand as if sculptured in relief.

In the right ventricle, two columns of the first order, rarely three, are met with—one on the anterior, the other on the posterior wall. The columns of the second order number two or three principal ones, extending from one wall to the other, or attached to two different points of the same wall. There also exist a considerable number of small ones intermixed with those of the third order. The latter are particularly abundant in the angles formed by the union of the two faces, where they interlace and give rise to more or less complicated areolæ.

Apex.—The *apex* of the right ventricle does not descend to the point of the heart, being distant from it about 1½ inches.

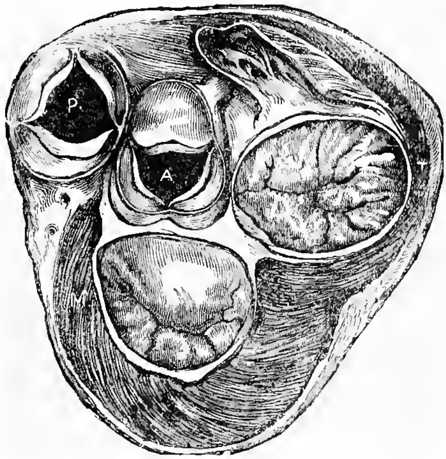
Base.—This has two large orifices—the *auriculo-ventricular* and the *pulmonary openings*.

Auriculo-ventricular opening.—Placed on a level with the constriction that divides the right heart into two superposed compartments, this orifice—widely open and almost a regular circle in outline—forms the communication between the auricle and ventricle. It is provided with a valvular fold that exactly closes the orifice when the ventricle contracts to propel the blood into the lungs, and which is termed the *tricuspid* (having three points) valve, in consequence of its form. This valve offers: 1. A superior border, attached to the entire margin of the auriculo-ventricular opening. 2. An inferior opening, free, cut into three festoons by three deep notches, and fixed to the ventricular walls, principally on the summits of the fleshy columns, by means of the tendinous cords which ramify on reaching the valve. One of these festoons—more developed than the others—is placed on the limit of the auriculo-ventricular and pulmonary openings; thereby constituting a kind of vertical partition that divides the ventricular cavity at its base into two compartments—a right or auricular, and a left or arterial. The other festoons are applied to the anterior and posterior walls of the ventricle. 3. An external face, which receives the insertion of a great number of tendinous cords. 4. An internal face, which becomes superior when the valve is raised to close the opening, when it constitutes the floor of the auricular cavity.

Pulmonary opening.—This orifice represents the entrance of the pulmonary artery. Situated in front and to the left of the preceding, but a little higher, it occupies the summit of a kind of infundibulum (the *conus arteriosus*) formed by the left compartment of the ventricle being prolonged upwards. It is perfectly circular, smaller than the artery to which it gives origin, as well as the auriculo-ventricular opening, from which it is separated by a kind of muscular spur, to which is attached the principal festoon of the tricuspid valve.

The pulmonary opening is furnished with *three valves*—the *sigmoid* (or *semilunar*), suspended over the entrance to the pulmonary artery, and, as has been ingeniously remarked (by Winslow), like three pigeons' nests joined in a triangle. These valves are remarkable for their thinness—a circumstance which does not interfere with their solidity. They present : an external, convex border, attached to the margin of the orifice and to the walls of the pulmonary artery ; a free border, straight when pulled tense, concave when left to itself, and sometimes provided in its middle with a small, very hard tubercle, the *nodule of Arantius* (*nodulus*, or *corpus Arantii*) ; a superior, concave face ; and an inferior, convex one. The sigmoid valves are raised and applied to the walls of the vessel at its entrance, when the ventricle contracts and sends the venous blood into the lung. When this contraction ceases, they fall back one against the other by that part of their inferior face next to their free border, so as to oppose the reflux of the blood into the ventricular cavity.[1]

Fig. 352.



SECTION OF THE HEART AT THE LEVEL OF THE VALVES.

P, Pulmonary artery; A, aorta; M, mitral valve; T, tricuspid valve.

Right Auricle.—The cavity of the right auricle represents a very concave lid or cover surmounting the auriculo-ventricular opening, and is prolonged, anteriorly, by a curved *cul-de-sac*. It offers for study this *anterior cul-de-sac*, a *posterior*, *external*, and *internal wall*, as well as a *superior wall* or *roof*, and the *auriculo-ventricular opening*, which occupies the whole floor of the cavity. This orifice has been already described.

The *anterior cul-de-sac* is in the appendix auricularis ; it is divided by a great number of muscular columns of the second and third orders (*musculi pectinati*), into deep and complex areolæ.

The *posterior wall* responds to the interauricular septum ; it is smooth, and usually marked by an oblique and more or less deep *cul-de-sac* (or depression), the remains of Botal's foramen. This depression is surrounded by the *ring* (or *isthmus*) *of Vieussens* (*annulus ovalis*), and is named the *fossa ovalis ;* it is only separated from the left auricular cavity by a thin membrane, a vestige of the

[1] It has been repeated, *ad nauseam*, that the occlusion of the arterial openings results from the juxtaposition of the *free border* of the sigmoid valves; even the small tubercle in the middle of this border, has been considered to play its part in closing the triangular central space left when these valves meet. In passing the finger into the pulmonary artery of a living animal, to explore the function of these membranous folds, it is readily perceived that they come in contact by a large portion of their convex face, and not alone by their free border. This arrangement is such, that we have with much difficulty tried to produce an insufficiency of contact by keeping one of the valves up against the walls of the vessel with the finger; but the others came down against the finger and applied themselves around it so as to exactly close the orifice.

valve (*Eustachian valve*) circumscribing the interauricular opening in the fœtus.[1]

In the wall are small orifices (*foramina Thebesii*) which lead to anastomosing vessels (*venæ cordis minimæ*) in its substance.

The *external wall* is areolated, and perforated behind and below by two orifices, the largest of which is the opening of the posterior vena cava, the other the opening of the large coronary vein. Both are destitute of valves, though these are found at a short distance in the coronary vein. The bronchial vein sometimes opens separately beside the latter.

The *internal wall* is smooth.

The *superior wall*, or *roof* of the auricle, shows the openings of the anterior vena cava and vena azygos ; the latter only is provided with valves, which are, however, not always present. On this wall are also remarked, in front, areolæ separated by muscular columns.

The thickness of the right auricular walls is very irregular, in consequence of the reliefs sculptured on the inner face of that cavity. In some points it is about $\frac{1}{3}$ of an inch, and in others, particularly in the small *culs-de-sac* formed by the reticulations, it is sometimes so thin as to appear exclusively formed by the union of the external and internal serous membrane.

(When the vena azygos opens behind, there is between it and the orifice of the anterior vena cava, a muscular layer with a free concave border, which forms a kind of valve of very variable extent. Behind this vena cava is a thick eminence—the *tuberculum Loweri ;* this has the form of a crescent, open in front, and elongated from right to left at the superior border of the septum. The anterior, or left border of the fossa ovalis, is thin and prominent, and constitutes the *Eustachian valve*[2]—a musculo-membranous fold of a semilunar shape, with a concave free border directed to the right and behind. It is of little use in animals, because of their horizontal position. Immediately beneath the posterior vena cava, and between it and the coronary vein, is a small membranous crescent—the *valve of Thebesius.*)

C. Red-blood (or Aortic) Heart.—This is also called the *posterior heart*, and more frequently the *left heart*, because it is situated behind and to the left of the dark-blood heart. Its general disposition otherwise exactly resembles that of the latter receptacle.

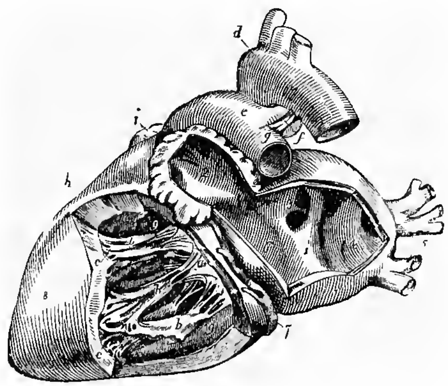
Left Ventricle.—This is a cylindro-conical cavity, the transverse section of which is irregularly circular. Its walls attain a thickness of from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches, except towards the apex of the heart, where they are extremely thin. They are less reticulated than those of the right ventricle, and exhibit several columns of the second order, as well as two enormous muscular pillars—an external and internal, for the attachment of the tendons of the auriculo-ventricular valve. The *apex* of the cavity forms a reticulated *cul-de-sac*, which occupies the point of the heart. The *base* is perforated by the auriculo-ventricular and the aortic openings. The *auriculo-ventricular opening*—precisely similar to that of the right ventricle—is provided with a circular membrane, the *mitral* (or *bicuspid*) *valve*, because it is cut into several festoons, of which two are the principal—the one

[1] Zangger and Zundel have observed instances of persistent foramen ovale in Foals, and even in Horses. Goubaux has collected fifteen cases of this kind, thirteen of which occurred in Bovines—aged from four months to twenty years—one in the Sheep, and another in the Dog. This anatomist also met with an abnormal communication between the two ventricles in an adult Horse. Chatin has studied a similar anomaly in a young Hemionus.

([2] The presence of a Eustachian valve in the Horse has been denied.)

anterior, the other posterior, simulating in their outline the two faces of a bishop's mitre. The anterior festoon is the largest, and is attached to the limit of the two orifices, isolating from the ventricular cavity a diverticulum which corresponds, in every respect, to the pulmonary infundibulum. The posterior festoon is applied to the walls of the ventricle. Between these two there are usually two secondary festoons, making up the total number to four; frequently there is an accessory fold, situated on the right side, and fairly developed; the valve is then tricuspid, like that of the right ventricle. Sometimes two of these rudimentary folds are found on the left side—making five festoons in all. The *aortic opening*—so named because it constitutes the origin of the aorta—is placed in front and to the left of the auriculo-ventricular opening, from which it is only separated by a thin muscular spur, to which is attached the adherent border of the great festoon or curtain of the mitral valve. It does not differ in anything from the pulmonary opening, and, like it, is provided with *three sigmoid* (or *semilunar*) *valves*.

Fig. 353.



LEFT CAVITIES OF HEART LAID OPEN.

1, Cavity of left auricle; 2, cavity of appendix auriculæ; 3, opening of two right pulmonary veins; 4, sinus into which left pulmonary veins open; 5, left pulmonary veins; 6, auriculo-ventricular opening; 7, coronary vein lying in auriculo-ventricular groove; 8, left ventricle; 9, 9, cavity of left ventricle. *a*, Mitral valve, its curtains connected by chordæ tendineæ to *b*, *b*, columnæ carneæ; *c*, *c*, fixed columneæ carnæ on inner surface of ventricle; *i*, point of appendix of right auricle.

Left Auricle.—As in the right auricle, this forms a kind of lid above the auriculo-ventricular opening. Smooth behind, in front, inwards and outwards, its cavity presents a reticulated *cul-de-sac*, which occupies the auricula; and a superior wall, also reticular, having from four to eight orifices—the openings of the pulmonary veins. These orifices have no valves. (*Carneæ columnæ* of the third kind are also present, but chiefly between the two posterior pillars; small ones are very numerous on the borders and summit of the ventricle. The columns of the second order are simple or ramous, and pass from the angles of union of the walls and the point of the cavity; others on the posterior wall go to the borders and the interval between the two pillars. The most remarkable are bands extending from one wall to the other, the two principal of which are long, strong, and ramous; they are fixed, on the one side, to the centre of the great posterior reliefs, and ascend to be implanted, on the other side, into the middle of the anterior wall.)

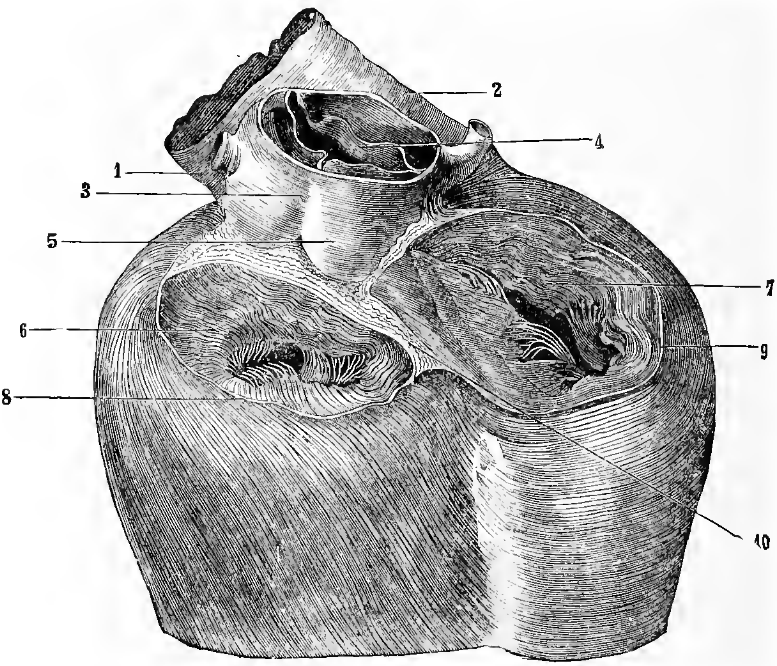
4. Structure of the Heart.

Preparation.—Before proceeding to dissect the muscular fibres of the heart, it is indispensable to keep that viscus in boiling water for half or three quarters of an hour. It should then be immediately immersed in cold water, to prevent the desiccation of the serous membrane covering it, and which must be at once removed. The furrows should then be cleared of their vessels and fat; this renders the superficial muscular fibres very apparent. The same result may be attained by immersing the heart in vinegar or dilute hydrochloric acid. To isolate the ventricles and unitive fibres from each other, the following procedure may be adopted: After removing the auricular mass and dissecting the fibrous rings, the unitive fibres around these are divided with the point of the scalpel, care being taken not to injure the proper fibres. Then, with the aid of the finger-nail or handle of the scalpel, follow the more or less artificial limit of these two series of muscular planes in a spiral manner; the vessels passing through the walls of the heart must be cut through. The same course is followed in the substance of the inter-ventricular septum, in order to separate the two sacs formed by the proper fibres.

(It will be found that the simplest and best way to prepare the heart for an examination of its fibres, is to steep it in a very weak dilution of hydrochloric acid. Remove the serous membrane, and the fibres can then be traced, layer by layer, from their origin to their termination.)

The muscular tissue composing the heart rests on a fibrous framework, disposed in rings around the auriculo-ventricular and arterial openings; it receives

Fig. 354.



AURICULO-VENTRICULAR FIBRO-CARTILAGINOUS RINGS.

1, Pulmonary artery; 2, superior border of the infundibulum; 3, aorta; 4, sigmoid or semilunar valves; 5, bulgings of the aorta corresponding to the semilunar valves; 6, left auriclo-ventricular opening; 7, right ditto; 8, left fibro-cartilaginous ring; 9, right ditto; 10, the two rings meeting together in the middle line.

vessels and nerves, and while covered in the internal cavities by two independent serous membranes, it is enveloped, externally, by another membrane of the same kind. An *annular framework, muscular tissue proper, vessels and nerves*, and *serous tunics*—such are the elements entering into the structure of the heart.

A. Fibrous Rings, or Tendinous Rings of Lower.—These are also named the *fibrous zones* of the heart, and are four in number: one for each of the openings at the base of the ventricles.

The two *arterial zones* (the *pulmonary* and *aortic*) constitute two complete rings, which are not disposed in a circular manner around the pulmonary aortic openings, but are divided into three regular festoons with their concavities superior and internal, and corresponds to the insertions of the three sigmoid valves. These zones are continuous, by their superior and external contour, with the walls of the arteries, from which they are only distinguished by their whitish-grey colour and slight elasticity, the arterial tissue being yellow and very elastic. Their internal and inferior outline sends three thin prolongations into the serous duplicatures of the sigmoid valves.

The *auriculo-ventricular zones* do not completely surround the openings they circumscribe. They are flat, brilliantly white tendons, laid one against the other at the ventricular septum, and against the aortic ring; they turn to the right and left around the auriculo-ventricular openings, but without joining at their extremities, which are dispersed as fibrillæ in the muscular tissue of the ventricles. Above, these zones give attachment to the muscular fibres of the auricles; below, to the ventricular fasciculi. Their internal and inferior border is prolonged into the mitral and tricuspid valves, and is continuous, through these valves, with the chordæ tendineæ of the ventricles. Some of these cords, generally the strongest, are even directly inserted into the auriculo-ventricular zones.

It must be noted that, in Solipeds, there is constantly found, at the point where the aortic and auriculo-ventricular zones lie against each other, a more or less developed cartilaginous body, which, in the larger Ruminants, is transformed into true bone. (Lavocat speaks of two cartilaginous points, one to the right, at the junction of the aortic with the left auriculo-ventricular ring and the cardiac septum; the other, less developed, on the left, at the origin of the left ventricular groove.)

B. Muscular Tissue (Fig. 355).—The muscular tissue of the heart is that of organic life, as it contracts independently of the will. Nevertheless, it is formed of red striped fibres, which differ from the striped muscles of the locomotory apparatus. They are granular and dark under the microscope, and ramify and anastomose in such a manner as to form an extremely fine network in the myocardium. From the joining end to end of the *segments of Weissmann*, there result simple or ramified prisms, the bases of which are notched like stairs. Each Weissmann segment comprises: 1. In the centre, one or two nuclei with a nucleolus. 2. Contractile cylinders of unequal length, around the nuclei. 3. A mass of protoplasm enveloping the nucleus, extending between the contractile cylinders, and forming a kind of sarcolemma. Between the fibres of the myocardium there is very little connective tissue, but there is a great number of blood-vessels and lymphatics.

The arrangement of the muscular fasciculi of the heart has been the object of numerous investigations, which have only complicated what was already known on the subject. We will endeavour to sum up, as simply as possible, this arrangement, in examining it successively in the ventricles and auricles.

1. Fibres of the Ventricles.—According to the remark of Winslow, we may compare the ventricles, in regard to the arrangement of the fibres composing them, to "two muscular sacs included in a third;" that is to say, each ventricle is formed of *proper muscular fibres*, covered externally by a layer of *unitive fibres*, which envelop the two ventricles in common.

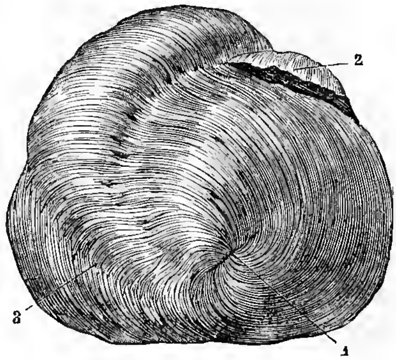
a. Proper fibres of the ventricles.—Taken altogether, these fibres represent, for each cavity, a hollow cone, open at both its extremities—at the superior extremity, by the auriculo-ventricular and arterial openings; and at the inferior extremity, by an aperture which admits the reflected fibres of the common layer. All form loops, attached by their extremities to the outline of the superior orifices, on the fibrous zones, and are rolled, more or less obliquely, around the axis of the ventricles. It is from the apposition of the right and left systems that the ventricular septum is formed.

b. Unitive fibres of the ventricles.—These are disposed as an external shell enveloping the proper fibres. They leave the fibrous zones at the base of the heart, and descend towards its apex: those of the right side, by inclining forward; the anterior, in following the direction of the great axis of the ventricles; those of the left face, by directing their course downwards and backwards; and the posterior, in rolling themselves from left to right around the left ventricle. On arriving near the point of the heart, they turn from left to right, and before to behind, in forming a spiral twist; then they are reflected from below upwards, to enter the inferior extremity of the ventricles, on the internal face of the proper fibres of which they spread and ascend to the fibrous zones at the base of the heart, where they terminate. Some of these reflected fibres are disposed in relief, to constitute the columnæ carneæ, and reach the

Fig. 355.

ANASTOMOSING MUSCULAR FIBRES OF HEART.

Fig. 356.



MUSCULAR WHORL AT THE POINT OF THE HEART.

1, Vortex or whorl with small opening in the middle; 2, auricle; 3, intercrossing of the anterior and posterior unitive or uniting fibres.

auriculo-ventricular zones through the medium of the chordæ tendinæ that directly connect these fibrous rings with the summits of the muscular pillars.

All the fibres do not reach the point of the heart to ascend to the fibrous zones; a certain number are reflected at different heights in the layer they form, and Gerdy has compared them to a number of horns placed one within the other, and flattened as are the walls of the ventricles.

Such is the general disposition of the unitive fibres of the ventricles; and it will be seen that they form a superficial and a deep or reflected plane, between which are comprised the fasciculi proper to each ventricular cavity.

The unitive fibres of the ventricles, therefore, form collectively a kind of figure 8, the smallest loop of which is at the point of the heart; there the fibres are heaped together, leaving in the centre of the loop a very small space, through which it is possible to pass a probe into the ventricle, without piercing anything but the external and internal serous membranes of the organ.

2. **Fibres of the Auricles.**—The fibres of the auricles are either common to the two cavities, or proper to each.

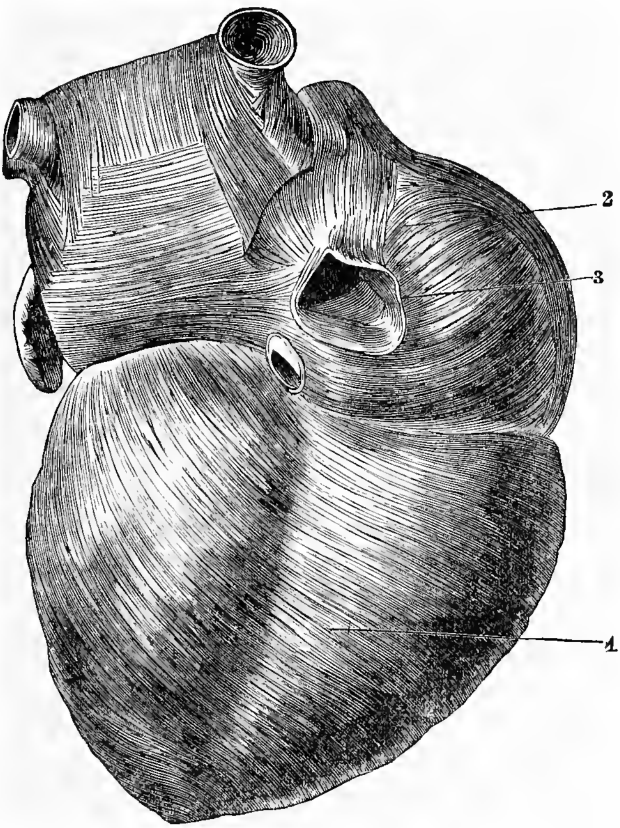
The *unitive fibres* constitute two thin bands—a right and left, carried from one auricle to the other.

The *proper fibres* are divided into several fasciculi, some of which are arranged in rings around the auriculo-ventricular opening; others in interwoven loops; and others, again, in sphincters, which surround the entrance of the veins.

These fibres are arranged in such a manner that, in contracting, they diminish the auricles by their superior and lateral planes and extremities, and propel the blood towards the auriculo-ventricular openings.

(The arrangement of the muscular fibres constitutes the most remarkable

Fig. 357.



POSTERIOR UNITIVE FIBRES, AND FIBRES OF THE POSTERIOR FACE OF THE AURICLES.

1, Posterior unitive fibres; 2, fibres of the right auricle; 3, fibres of the posterior vena cava.

feature in the anatomy of the heart. We have seen that the auricles, as well as the ventricles, possess not only fibres proper to each compartment, but also unitive or common fibres, which assure the simultaneousness in action of the similar or homologous cavities. Besides, the fibres of the auricles and those of the ventricles are distinct, and not continuous; so that, from their independence of each other, it results that these two sections of the heart may act separately, and contract, not simultaneously, but alternately—a condition indispensable to the free course of the blood. The extremely fine and close connective tissue uniting the muscular fibres, and the anastomosing of these, is another peculiarity of structure that must be favourable to the solidarity of their action, which ought to be simultaneous. In the healthy organ, adipose tissue is only found in the grooves on its surface, around the vessels lodged in them, and particularly at its base, between the large arterial trunks.)

C. Vessels and Nerves of the Heart.—Blood is carried to the muscular tissue of the heart by two large vessels—the *coronary arteries*. They emanate from the trunk of the aorta, at the sigmoid valves, and each divides into two principal branches—one passing along the horizontal, the other in the vertical furrow of the heart. Collectively, these arteries form two circles, which surround the heart in intersecting it at a right angle in the auriculo-ventricular groove.

The blood is carried from the walls of the heart by a single but important *vein*, which empties itself into the right auricle.

The *lymphatics* follow the arteries, passing along the visceral layer of the pericardium, and entering the cluster of glands situated near the base of the heart. (The epicardium, as well as the endocardium—especially in the ventricles—has a large network of fine lymphatics, the walls of which consist of only a single layer of intimately adhering cells. Lymphatics are also numerous in the myocardium, and amongst the muscular fibres there are lacunæ or spaces lined by endothelial cells—the origins of the lymphatics. The lymph passes into lymphatic glands lying between the aorta and trachea, flowing thence into the thoracic duct. No lymphatic vessels have been traced upon the chordæ tendineæ, and very few upon the auriculo-ventricular and semilunar valves.)

The *nerves* of the heart, furnished by the cardiac plexus, come from the pneumogastric and sympathetic. The tubes are small, and show some cells in their course. In addition to these, the heart is provided with a particular ganglionic system, to which Remak, Bidder, and Ludwig have called attention. It is believed that there exist three ganglia in different points of the cardiac parietes, and that on these depend the movements of the organ. (Nerve-cells are most numerous in the basal and middle parts of the ventricles of the heart of the Dog, Sheep, Calf, and Pig, chiefly in the anterior and posterior inter-ventricular grooves and on the left ventricle. According to Carpenter, the nerves of the heart are: 1. Minute ganglia and fibres of the sympathetic, situated in the walls of the cavities, and especially in the auriculo-ventricular furrow. 2. Fibres derived from the cervical portion of the sympathetic, and passing to the cardiac plexus, between the aorta and pulmonary artery. 3. Cerebro-spinal fibres entering the inferior cervical or stellate ganglion, and proceeding to the same plexus, and probably derived from a centre situated in the brain and spinal cord. 4. Fibres coursing in the vagus—*nervi cardiaci*—and originating in a centre situated in the medulla oblongata. The first three of these ganglia and fibres probably collectively constitute the excito-motor system of the heart; the fourth is an inhibitory, restraining, or regulo-motor centre.)

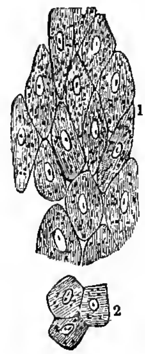
D. Serous Membranes of the Heart.—These are three in number—two internal, or *endocardial*, one of which occupies the right, the other the left cavity; and an external—epicardial—a dependency of the fibro-serous sac which contains the heart.

1. *Internal serous membranes, or endocardia.*—These two membranes, independent, like the cavities they line, are spread over the auricular and ventricular walls, covering the tendinous or muscular columns attached to these walls, and

are prolonged into the veins and arteries, to form the internal tunic of these vessels. At the auriculo-ventricular and arterial openings, they constitute a duplicature for the valves situated there. These valves are, therefore, due to the projection of a circular fold of the endocardium, between the two layers of which is connective tissue mixed with elastic fibres in the auriculo-ventricular valves, and a layer of connective tissue on each surface of the elastic fibres in the semilunar valves. It is worthy of remark that the elastic fibres of the valves are more abundant in the left than the right side of the heart.

The endocardium of the right heart has a red tint, which is deepest in the ventricle. In the left heart, this tint is slightly yellow, especially in the walls of the auricle, which may be attributed to the presence of a thin layer of yellow elastic tissue that covers the adherent face of the membrane.

Fig. 358.



EPITHELIUM OF THE ENDOCARDIUM.

1, Nucleated cells assuming the fusiform figure; 2, polygonal nucleated cells.

The endocardium consists of two layers : 1. A thin bed of connective tissue, connecting it to the muscular structure, in which elastic fibres are pretty uniformly distributed, as well as smooth muscular fibres, especially in the left heart. 2. An endothelium, consisting of a single or double layer of somewhat elongated, polygonal, tesselated nucleated cells.

2. *External serous membrane* (*epicardium*).—This is the visceral lining membrane of the pericardium, the description of which follows

5. The Pericardium (Fig. 255, c).

Preparation.—Place the animal in the second position, and remove the sternal ribs by separating the cartilages and luxating their costo-vertebral articulations. This procedure permits the study of the situation and general disposition of the heart and pericardium. But in order more easily to examine the reciprocal arrangement of these two parts, it is necessary to extract them from the thoracic cavity by tearing through the sternal insertion of the pericardium.

The *pericardium*, or proper serous covering of the heart, is a membranous sac enclosing that organ, fixing it in the thoracic cavity, and favouring its movements by its polished surface.

This sac is formed by a fibrous layer, within which is spread a serous membrane, divided into two parts—one parietal, the other visceral.

The *fibrous layer* of the pericardium presents somewhat the general form of the heart. Its *internal surface* is covered by the parietal portion of the serous membrane. The *external surface* corresponds to the two layers of the mediastinum. Its *summit* (or *apex*), depressed on each side, and elongated from before to behind, is firmly attached to the superior face of the sternum, from the fourth rib to the origin of the xiphoid cartilage. By its *base*, it is fixed to the large vessels going to and leaving the heart, where it is continuous with their connective-tissue sheath, and where it sends some fibres to the longus colli.

The *serous membrane of the pericardium* has been well compared by Bichat to a cotton nightcap, the external part of which would represent the parietal layer, and the inverted part the visceral portion of the membrane. The *parietal layer* adheres in the most intimate manner to the internal face of the fibrous tunic, and is reflected to form the visceral portion, around the pulmonary arteries and the aorta for a certain distance from their origin, and on the pulmonary veins. The *visceral layer* envelops in common the two arterial trunks, covers a small part of the venæ cavæ—particularly the anterior—spreads over the insertion of the pulmonary veins, and then descends on the auricles and ventricles. The free face of this layer is in contact with that of the parietal layer; the adherent face is applied to the tissue of the heart or that of the large vascular trunks, except at the horizontal and vertical grooves, where it rests on the coronary vessels, and on the mass of adipose tissue constantly accumulated on their track.

In the living animal, the cavity of the pericardium is never entirely filled by the heart, so that the movements of that organ are allowed much more liberty. Otherwise, as it does not contain any gas, nor a sensible proportion of fluid,[1] its walls are immediately applied to the surface of the heart.

The two layers of the pericardium are covered by a layer of endothelial polygonal cells.

Blood reaches the pericardium by the mediastinal arteries. Its walls receive some sympathetic nerve-fibres.

(The epicardium is composed of a fine network of connective tissue and elastic fibres, as well as bundles of non-striped muscular fibres; these resist the distension that occurs when the heart contracts and a great strain is thrown upon the endocardium. Gurlt, in 1867, described a thin muscle, nine inches long, situated between the pericardium and the diaphragm of the Horse.)

6. Action of the Heart.

The function of the heart is to maintain the circulation of the blood, by the rhythmical contractions of its two cavities. The right side propels that fluid to the lungs, whence it returns to the left side, and from this it is thrown into all parts of the body, after which it is brought back again to the right heart. These contractions take place simultaneously in the two cardiac compartments.

In taking the heart at the moment when it is in a state of repose—that is, in the intervals between the two contractions—we find that its two pouches are being rapidly filled with the blood brought to it by the veins. When sufficiently replete, the auricles slightly contract aud push a portion of the fluid they contain into the ventricles—these contracting immediately after, to propel the blood into the arteries. This passage of the blood into the arteries is a necessary consequence of the contraction of the ventricles, as at the moment when this occurs the auriculo-ventricular valves are raised, and so prevent the reflux of the blood into the auricles. This fluid is then forced to enter the arterial orifices, the valves of which are separated under the impulsive effort communicated to the column of blood. When the heart returns to a state of repose, these valves fall down, preventing the return of the blood into the ventricles; while the mitral and tricuspid valves subside against the walls of these cavities, and thus again allow the passage of blood through the auriculo-ventricular openings.

By the term *systole* is designated the contraction of the heart's cavities, and by *diastole*, the repose or relaxation of its tissue. For each revolution of the heart there is, therefore: 1. The *general diastole* of the organ, during which the two cardiac cavities are filled by the afflux of venous blood. 2. The *systole of*

[1] With Horses in health, the fluid exhaled into the pericardium is barely sufficient to moisten and lubrify the free surface of its serous membrane. But in those worn out and enfeebled by age, privations, or disease, it is not rare to see it accumulated in greater or less quantity. To verify this, however, an examination ought to take place *immediately* after death, as the accumulation of fluid in the serous cavities by cadaveric exhalation is common in all animals.

the auricles, the effect of which is the repletion of the ventricles. 3. The *systole of the ventricles*, propelling the blood into the arterial systems; after which comes another period of general diastole.

Differential Characters in the Heart of the other Animals.

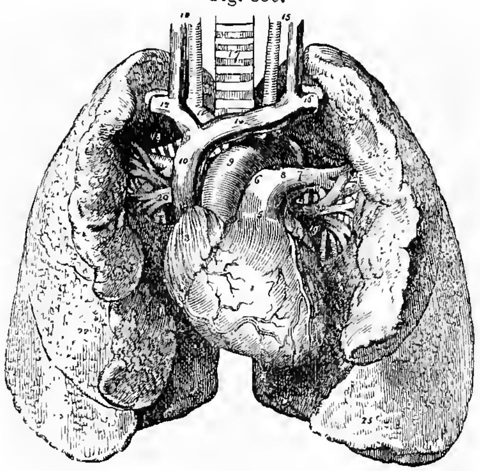
In the **Ox, Sheep,** and **Goat,** the ventricular mass of the heart is more regularly conical than in Solipeds; it has three longitudinal grooves, one of which is accessory and passes behind the (left) ventricle.

In the **Ox** two small bones, named *cardiac bones*, are found in the substance of the aortic zone. The largest is in the right side, at the point where the arterial ring is approximated to the auriculo-ventricular zones; the other, situated in the left, is perhaps not constantly present. The first is triangular in shape, curved to the right, and its base is directed upwards. The right face lies against the auriculo-ventricular opening; the left is covered by the walls of the aorta at its commencement. It is about an inch in length. (The Ox's heart averages from about 3½ to 4½ lbs.; that of the Sheep, from 5½ to 7 oz. It is more elongated and pointed in Ruminants than in the Horse or Pig. The *large* bone in the Ox's heart is elongated from before to behind, flattened laterally and curved to the left; its surface is roughened, and its length is sometimes about 2 inches. The left, or *small* bone, is usually flattened on each side and triangular, one of its points is directed forwards, another backward, and a third inferiorly; its length is about three-quarters of an inch when fully developed. Besides the Ox, a small cross-shaped bone is found in the heart of the Sheep, Pig, Camel, Deer, Giraffe, and sometimes in the Horse. Remak found in the pericardium of the **Ox,** at the border of the left auricle, a row of villi similar to those discovered in the border of the chicken's heart.)

The heart of the **Pig** resembles that of the Horse; its direction is a little more oblique, and the pericardium is fixed to the sternum from the third rib to the xiphoid appendix, as well as to the diaphragm. (The cartilage is not ossified until a late period.)

In the **Dog** and **Cat,** the heart is ovoid or nearly globular. It rests almost entirely on the upper face of the sternum; its anterior face has become the inferior, and its point, directed backwards, touches the anterior surface of the diaphragm. The pericardium is attached to the aponeurotic centre of the diaphragm.

Fig. 359.



HUMAN LUNGS AND HEART (FRONT VIEW).

1, Right ventricle; 2, left ventricle; 3, right auricle; 4, left auricle; 5, pulmonary artery; 6, right pulmonary artery; 7, left pulmonary artery; 8, ligament of ductus arteriosus; 9, arch of aorta; 10, superior vena cava; 11, arteria innominata; 12, right subclavian vein, with the artery behind it; 13, right common carotid artery and vein; 14, left vena innominata; 15, left carotid artery and vein; 16, left subclavian vein and artery; 17, trachea; 18, right bronchus; 19, left bronchus; 20, 20, pulmonary veins; 21, superior lobe of right lung; 22, middle lobe; 23, inferior lobe, 24, superior lobe of left lung; 25, inferior lobe.

Comparison of the Heart of Man with that of Animals.

The human heart is ovoid, and similar to that of Carnivora; the ventricular mass is not acute at its apex, as in Solipeds and Ruminants. Its direction is modified in consequence of the antero-posterior flattening of the chest. It is situated across the median plane of the thorax; its right face in animals has become the anterior face in Man, and is applied to the sternum; the anterior border is in him the right border, and the posterior the left border.

The organ is suspended obliquely downwards, forwards, and to the left; consequently, the right auricle is to the right of the sternum, between the third and fourth ribs, and the point on a level with the sixth left intercostal space. The auricular appendages, particularly the right, are more rounded and bulging than in animals. The pulmonary veins, four in number, open on the upper face of the left auricle.

There are no essential differences to be noted in its internal conformation. We may indicate the presence of a fold that passes from the ring of Vieussens to the opening of the inferior vena cava; this is the *Eustachian valve.* We may also mention the Thebesian valve at the entrance of the coronary vein.

The fibrous rings and muscular fasciculi are disposed as in the Horse.

The *pericardium* is a conical sac; but instead of its base being presented upwards, it rests against the tendinous centre of the diaphragm; its summit is lost among the large vessels; and it adheres to the posterior face of the sternum.

SECOND SECTION.

THE ARTERIES.

CHAPTER I.

GENERAL CONSIDERATIONS.

Definition.—The centrifugal vessels which carry the blood from the heart to the various organs, are named *arteries.*

Division.—These vessels proceed from the heart by two trunks, which are perfectly independent in the adult animal; they originate, one in the right ventricle, the other in the left.

The first of these trunks—which carries the dark blood—is the *pulmonary artery.* The second conveys the red blood, and is named the *aorta.* There exist, therefore, two groups of arteries—the *pulmonary system*, and the *aortic system.*

General Form.—Single at their origin, the two arterial systems soon divide into less voluminous trunks, which again subdivide into successively decreasing canals, until at last their diameter becomes reduced to an extreme degree of tenuity. In a word, the arterial trunks present the ramous disposition of dicotyledonous plants. The total volume of the secondary trunks exceeds that of the primary trunk, and the same relation exists between the respective dimensions of the branches and their ramifications, to the ultimate divisions of the artery. In tracing all the ramifications of one of these systems to a single canal, it will be found that this canal is incessantly increasing, from its origin to its termination, and that it represents a hollow cone with its apex at the heart.[1]

Particular Form.—Each artery is cylindrical in form, whatever its volume may be. When the diameter of these vessels is measured at their origin and

[1] Berryer-Fontaine again discusses this arrangement, and asserts that it is imaginary. According to his calculations, the arterial blood in Man circulates in a cylinder, and not in a cone. The measurements and the calculations we have made with regard to the arteries of Solipeds, have demonstrated once more that the volume of the terminal branches of an artery is greater than that of the latter. Consequently, we adhere to the old belief.

their termination, between two collateral branches, no sensible difference is perceived.

Mode of Origin.—The arteries are detached in an angular manner from the parent branches. Sometimes the angle of separation is more or less acute—this is most frequently the case; sometimes it is at a right angle, and at other times it is obtuse. It will be readily understood that the degree of this angle exercises a somewhat marked influence on the course of the blood. For example, the blood from a principal vessel, in passing into the canal of a secondary one which springs from it at an obtuse angle, must experience a notable check in its impetus, because of the change in direction it has to encounter; on the contrary, the rapidity of the current is not modified to any appreciable degree in those vessels which separate from them at a very acute angle. Towards the point of separation, there is always remarked, in the interior of the vessel, a kind of spur, the sharp border of which is towards the heart—thus dividing the current of blood and diminishing the resistance. This spur resembles in its arrangement the pier of a bridge, against which the waters are divided to pass on each side. (When a short trunk divides abruptly into several branches, proceeding in different directions, it is termed an *axis*. A very peculiar feature in the division of arteries, however, and one which will be made amply conspicuous in the following description, is their bifurcation or dichotomous arrangement, which prevails so largely.)

Course.—In the course pursued by an artery, it is necessary to consider the *situation* occupied by the vessel, its *direction*, *relations*, and the *anastomoses* which establish communication between it and the neighbouring vessels.

Situation.—The arteries tend constantly to recede from the superficial parts, and to become lodged in the deeper regions; in this way they are removed from the hurtful action of external causes—a tendency all the more marked as the arteries are more considerable in volume, but which ceases to be manifested in the less important ramuscules. These vessels, therefore, occupy either the great cavities of the trunk, or the deep interstices on the internal face of the limbs; when they pass over an articulation, it is always on the side at which flexion occurs. But in the limbs, for instance, the joints are flexed alternately in opposite directions, and it then happens that the arteries in these regions have a slightly helicoid (or spiral) arrangement. This is evident in the case of the femoral artery, which passes round the inner face of the femur to become the popliteal artery; and also in the humeral artery, which is at first situated on the inner side of the scapulo-humeral articulation, then winds around the humerus to be placed in front of the elbow-joint.

Direction.—The arteries are sometimes rectilinear, and at other times more or less flexuous. The latter disposition is evidently intended to prevent laceration of the vessels in organs capable of elongation and contraction, as may be remarked in the tongue; or to moderate the impetus of the blood, as in the internal carotid arteries.

Relations.—In their course, the arteries may be in contact with the viscera, nerves, muscles, bones, skin, and connective tissue.

a. In nearly every part of the body, the arteries maintain the most intimate relations with the veins—sometimes with two of these vessels, when the artery is placed between them; sometimes with only one, which is always more superficial.

b. The arteries are usually accompanied by nerves belonging to the cerebro-spinal or sympathetic systems. Those of the latter category are distinguished by the reticular interlacing they form around the visceral arteries; their structure will be alluded to presently.

c. Lodged, for the most part, in the interstices of the muscles, the arteries contract relations with these organs which it is very important to know, from a surgical point of view. Some of these muscles lie parallel with important arteries, and for this reason have been designated *satellite muscles;* they serve to guide the surgeon in searching for the arteries, by the more or less salient relief their presence affords beneath the skin.

It is worthy of remark that the arteries are not included in the fibrous sheaths enveloping the muscles; these vessels nearly always occupy, with the nerves which accompany them, special lodgments from the approximation of several aponeurotic sheaths. When they pass through the substance of a muscle —which sometimes happens—they are covered by a fibrous arch or ring, which protects them from compression during muscular contraction—the arch or ring receiving on its convexity the insertion of fibres from the muscle.

d. Nothing is more common than to see the arteries in direct relation with the bones—as, for instance, the aorta, intercostals, etc. Neither is it very rare to find a more or less thick layer of muscle between the arteries and portions of the skeleton. In every case, a knowledge of the relations between the arteries and bones is important to the surgeon; as it enables him to interrupt the circulation temporarily in these vessels, by exercising external pressure on the points of their course which correspond to the several bones, and thus diminish their calibre by flattening them.

e. In consequence of their deep situation, the arteries are, in general, distant from the skin; there are, nevertheless, some which course immediately beneath that membrane; but these are only found about the head and in the extremities.

f. Lastly, all the arteries are enveloped by a layer of connective tissue, which forms around them a kind of sheath, generally difficult to tear with the fingers, and which isolates from the neighbouring parts, but chiefly the veins. This connective tissue—more or less abundant according to the regions—is always loose enough to allow the arteries to roll and be displaced with the greatest facility, and thus to glide away from sharp bodies accidentally introduced into the tissues.

Anastomoses.—Very often the arteries are united to each other by communications, which have received the name of *anastomoses*, and which assure the equable distribution of the blood in regulating its flow. There are distinguished:

1. *Anastomoses by convergence*—formed by two vessels joining at their terminal extremity in an angular manner, to form a third and more voluminous trunk.

2. *Anastomoses by arches* or *by inosculation*—due to the junction of two principal branches, which are inflected towards each other, meet, and unite to form a single and curvilinear canal.

3. *Anastomoses by transverse communication*—represented by ramifications thrown transversely between two parallel arteries.

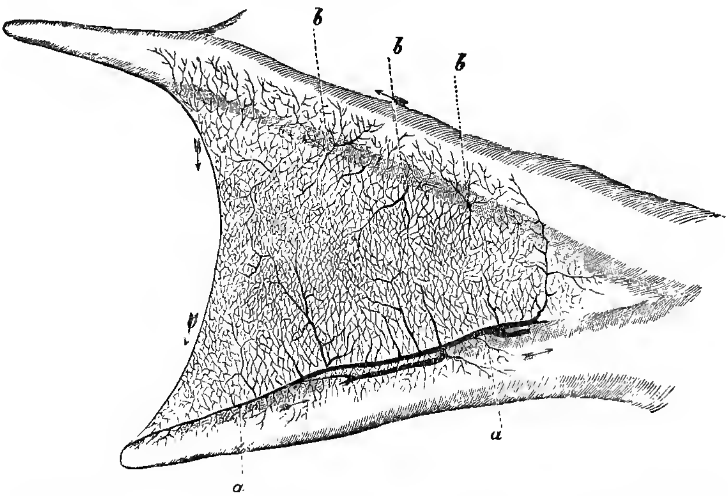
4. *Mixed* or *composite anastomoses*—in which are found a combination of the different types enumerated above.

A knowledge of the anastomoses of vessels is of the highest practical interest; as these communications permit the surgeon, in extreme cases, to tie the principal artery of a region without the latter experiencing any considerable nutritive disturbance; the blood continuing to arrive by the collateral vessels which, at first very small, gradually dilate from the eccentric pressure to which their walls are submitted. But these anastomoses, if they offer this immense advantage, have also their inconveniences: we refer to the difficulties experienced in arresting hæmorrhage in wounds of certain organs, owing to the relations of the principal vessel with its communicating collaterals.

Mode of Distribution.—The branches an artery distributes in the neighbouring organs are distinguished as *terminal* and *collateral*. The arteries, after pursuing a certain course, divide into several branches—nearly always two, which, as new arteries, continue the original vessel and take the name of *terminal branches*, because they really begin at the terminal extremity of that vessel.

The *collateral vessels* arise at various distances along the course of the arteries,

Fig. 360.



WEB OF FROG'S FOOT STRETCHING BETWEEN TWO TOES, SHOWING THE BLOOD-VESSELS AND THEIR ANASTOMOSES.

a, *a*, Veins; *b*, *b*, *b*, arteries, the capillaries being between.

and proceed in a lateral direction; they increase in number as the arteries become more superficial.

The distinction between the terminal and collateral branches of arteries is not always easy to establish, and is far from having an absolute value; it possesses, nevertheless, some importance, as it greatly facilitates description.

Termination.—Arteries terminate in the substance of the tissues by extremely fine and numerous ramuscules, which so frequently anastomose with each other as to form a plexus or microscopical network, the meshes of which are very close. These constitute the *capillary system*, which again gives rise to ramifications of gradually increasing size—the *veins*. The *capillary system* is, therefore, nothing more than a network of microscopical canals intermediate to the arteries and veins.

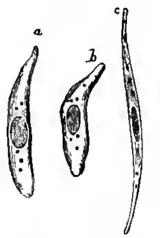
In the erectile tissues, the mode of termination is different; the small arteries sometimes opening directly into the cells placed at the origin of the veins, without passing through a capillary plexus. In describing the genital organs, we shall notice, in detail, the termination of the arteries in the cavernous tissues.

Structure.—The walls of arteries offer a certain rigidity, which permits these vessels to remain open when they are emptied of blood. The ancients believed this was their normal condition, and that they were filled with air during life. This was a grave error, as they contain nothing but blood. The gaping of the arteries must be attributed solely to the physical properties of the tissues composing their walls.

These walls comprise three tunics—an *internal*, *middle*, and *external*.

The *internal tunic* (*tunica intima*) is continuous with the endocardium of the left heart on the one part, and on the other with the capillaries and veins. For a long time it has been regarded as a serous membrane, but it has not absolutely the same texture. It is composed of a simple endothelial layer which is in contact with the blood, and is formed by fusiform cells that slightly bulge where their nucleus is. The endothelium lies upon a layer of very fine elastic tissue (the *fenestrated membrane* of Henle), perforated by openings which are occupied by

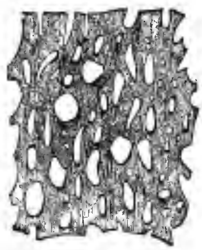
Fig. 361.



EPITHELIAL CELLS OF BLOOD-VESSELS.

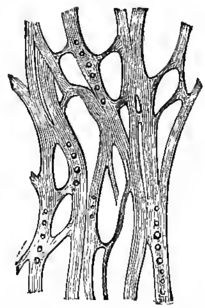
a, *b*, From a vein; *c*, from an artery. Magnified 350 diameters.

Fig. 362.



FENESTRATED MEMBRANE FROM THE CAROTID ARTERY OF THE HORSE. Magnified 350 diameters.

Fig. 363.



NETWORK OF COARSE ELASTIC TISSUE FROM MIDDLE COAT OF PULMONARY ARTERY OF THE HORSE, THE FIBRES BEING PIERCED WITH CIRCULAR OPENINGS. Magnified 350 diameters.

a slightly fibrillated connective substance, and by ramifying and anastomosing cells. Beneath this layer there is another, also composed of fine elastic and connective fibres lying in a transverse direction, and which is attached to an elastic layer (*internal elastic layer*) that determines the external limit of the deep tunic of arteries in the aorta; this layer is separated from the preceding by the network of Langhans.

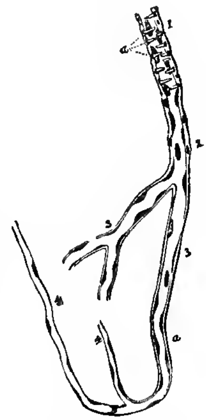
The *middle tunic* (*tunica media*) is remarkable for its thickness, its elasticity, and its yellow colour in the principal vessels. It has for base several elastic parallel layers, united by means of networks of fibres of the same kind, and having spaces between them which are occupied by connective tissue and non-striped muscular fibres; these are arranged in a circular manner around the vessels. In the umbilical and splenic (and also in the aorta, iliac, anterior mesenteric, and renal) arteries, there are longitudinal muscular fibres. The proportion of these two elements varies with the size and situation of the artery. In the large trunks—such as the aorta, the elastic is more abundant than the contractile tissue; in the medium-sized vessels they are about equal; but in the small arteries, in which the contractile force of the heart is lost because of their distance from it, the muscular fibres almost exclusively compose the middle tunic.

The *external tunic* (*tunica adventitia*) is only a layer of connective tissue, with some longitudinal recticulated elastic fibres in its deeper part. Though this tunic is very thin, yet it is strong; as a ligature tied tightly around an artery will rupture the other tunics, but not this.

The structure of the *capillaries* is not the same as that just described, but is modified in proportion as they are fine. In the smallest capillaries, the walls are formed by a thin amorphous membrane, in which (oblong) nuclei are somewhat regularly disseminated; in the finer arterioles, another layer external to this (the *contractile layer*), and containing transverse nuclei, is observed; and in the larger arterioles—those immediately succeeding the small arteries, these two nucleated layers are enveloped by a thin tunic of connective tissue (*tunica adventitia*).

(The most minute capillaries are merely tubes formed by a single layer of transparent, thin, nucleated, endothelial cells, joined by their margins. When perfectly fresh, the capillary does not show the edge of the cells, owing to the uniform refractive property of the wall of the tube. The nuclei show an internuclear plexus of fibrils. The cells are united by cement substance, and here and there minute dots or slits may be seen, which have been supposed by some authorities to be openings—*stomata*, or *stigmata*. The narrowest meshes of capillaries occur in the lungs and liver, and the wider in muscle, beneath serous membranes, and in the organs of sense. The widest capillaries are found in the liver, and the narrowest in the retina and muscle.)

Fig. 364.



TRANSITION OF A MINUTE ARTERY OF THE BRAIN INTO CAPILLARY VESSELS.

1, Minute artery; 2, transitional capillary; 3, coarse capillary with thick coat, represented by a double contour line; 4, fine capillary with single contour. The nuclei are seen widely scattered in 4 and 3; more closely congregated in 2; and still more so in 1, where they form an epithelium. *a*, Transverse elongated nuclei of muscular cells, the incipient muscular coat of the artery.

Vessels and nerves.—The arteries are provided with vessels termed *vasa vasorum*, which are furnished either by the arteries themselves, or by neighbouring vessels. These vasa vasorum form a superficial network with quadrilateral meshes, and a deep plexus, the principal branches of which are helicoidal. The majority of anatomists believe that this plexus does not extend beyond the external tunic.

The lymphatic vessels maintain intimate relations, in certain regions, with the capillaries. In the brain and spleen there has been discovered, around the arterial capillaries, a vessel that completely envelops them, and which has been named the *lymphatic sheath*.

The *nerves*, designated *vasa motors*, accompany the vessels and penetrate the muscular tunic, in which they are distributed. These vasomotor filaments join the branches of the capillary plexuses, and form, at the points where they meet each other, ganglionic enlargements; from these arise the fibres of Remak, the termination of which is unknown.

Anomalies in the Arteries.—In their arrangement, the arteries very often present anomalies which the surgeon should be guarded against. These usually are related to their number, their point of origin, and their volume. In a purely anatomical and physiological point of view, however, these anomalies are of no moment; as it matters little whether the blood comes from one source rather than another, or that a collateral vessel becomes the principal at the expense of the parent trunk, provided its relations are not altered, and the principle of immutability of connections is maintained.

Preparation of the Arteries.—This requires two successive operations: 1. Injection. 2. Dissection.

Injection of the arteries.—The object to be attained in injecting these vessels, is to introduce into their interior a solidifiable substance which will cause them to assume the volume and conformation they presented during life, when they are filled with blood.

Tallow, coloured by lamp-black, is the most convenient and general injecting material. Sometimes a solution of gelatine, with the addition of a certain quantity of plaster of Paris, is used; but this is seldom employed in the French schools. A copper or brass syringe, and a cannula with a stop-cock to fit on its extremity, are the only instruments necessary to propel these matters into the arteries.

The following are the details of the operation, when it is desired to make a general injection:—The animal being placed on a table, the carotid artery is exposed by an incision in the jugular channel, and opened longitudinally. A ligature is applied above the opening, and the tube, with the stop-cock, is firmly fixed in the cavity of the artery towards the heart by a second ligature. The injection, previously prepared, is taken up by the syringe, which is fitted into the tube, and the piston pushed, in order to drive the contents of the instrument into the arterial canals.

To perform the operation successfully, the following precautions are to be attended to: 1. Inject the vessels of an animal killed by effusion of blood, and yet warm. 2. If suet is employed, and which is always to be recommended, make it so hot that the finger can scarcely endure it. When it is colder than this it solidifies too quickly, and when hotter it shrivels up the sigmoid valves, passes into the left ventricle, and from thence into the auricle and pulmonary veins—an accident generally attributed to the too-powerful force applied to the piston of the syringe. 3. Do not make any undue pressure on the piston, though this does not strain the sigmoid valves so frequently as is believed. 4. Cease injecting when the arteries react, by their elasticity, on the piston, so as to drive it back in the syringe.

In order to ensure the retention of the injected matter in the arteries, and prevent the sigmoid valves being forced, a cork may be introduced into the aorta through the left ventricle, and firmly tied there by a strong ligature; the cork should have a transverse notch for the reception of the ligature.

Instead of injecting by the carotid, a long curved cannula may be fixed to the aorta itself, after making an opening in the left side of the chest, on a level with the heart, by the ablation of two segments of the ribs, and incising the pericardium and left auricle to introduce it. This mode allows the tallow to be injected at a very high temperature, and gives the best results, for it can then penetrate to the capillaries, if we only know how to manage it; in certain organs the injected matter may even be made to return by the veins.

But no matter what procedure may be adopted, there are several parts into which the tallow can never be made to enter by a general injection; these are the four extremities. So that a special operation must be resorted to, in order to fill their vessels. After separating them from the trunk, by sawing them through above the knees and hocks, they should be allowed to steep for two hours in water, constantly kept up to a temperature of from 140° to 160° Fahr. at most; it is then easy to inject them, either by the posterior radial artery, or the anterior tibial, after tying those branches which may be open at the cut extremity of the limbs.

If it is desired to make partial injections in other parts of the body, it will be better not to separate them from the trunk; but only to tie those vessels which anastomose between the arteries to be filled and those which are not. For example, to inject the arteries of the head, it suffices to push the mixture into one of the common carotids, after ligaturing the other in the middle of the neck, and both vertebrals in the space between the two portions of the scalenus muscle.

We may give the tallow more fluidity, and a higher degree of penetration, by mixing with it a little spirits of turpentine; or more consistence, in adding to it a small proportion of beeswax.

The two following mixtures are borrowed from Cruveilhier's Anatomy:—

Tallow	9 parts.
Turpentine	1 part.
Ivory Black, mixed with spirits of turpentine . .	2 parts.

For preservative injections:—

Beeswax	1 part.
Tallow	3 parts.
Vermilion, indigo, or Prussian blue, previously mixed in oil of turpentine	A sufficient quantity.

Of course, it is well understood that these instructions are only intended for the dissecting-room injections necessary for the study of descriptive anatomy. To inject the capillaries, it is requisite to have recourse to other substances and other procedures. Suffice it to say that these injections are made with cold fluids, such as varnish, alcohol, or spirits of turpentine, holding in suspension extremely fine colouring matter, gum arabic dissolved and coloured by a substance also in solution, etc., or, better still, colours rubbed up in oil, and mixed with oil of turpentine.

Dissection of the arteries.—There are no general rules to be given for the dissection of arteries.

CHAPTER II.

Pulmonary Artery (Fig. 349, *e*).

Preparation.—The pulmonary artery is not filled by the general injection mentioned above. It is directly injected by propelling the tallow into the right heart by the anterior vena cava, after tying the posterior vena cava.

The *pulmonary artery* arises from the infundibulum (*conus arteriosus*) in the right ventricle, is directed upwards and then backwards, describing a curve the concavity of which is infero-posterior; on reaching the left auricle, it divides into two secondary arteries—one for each lung. These arteries enter the pulmonary tissue with the bronchi, and exclusively ramify in it.

The pulmonary artery accompanies the trunk of the aorta on the right side, and is enveloped with it in a serous sheath, a dependency of the visceral layer of the pericardium. At its origin, it is flanked before and behind by the auricules and the cardiac vessels. About the middle of its course, it is united to the posterior aorta by means of a yellow elastic fibrous cord (the *ligamentum arteriosum*), the remains of the ductus arteriosus which, in the fœtus, establishes a large communication between these two vessels (Fig. 349, *e*).

The walls of the pulmonary artery are much thinner than those of the aorta, and are yellow and elastic, as in the other canals of the same order. We, however, have seen them in an Ass, formed almost entirely of red muscular fibres, analogous to the fasciculi of the heart.

It may be repeated that the pulmonary artery conveys to the lungs the dark blood carried to the right heart by the veins of the general circulation.

CHAPTER III.

THE AORTA.

If we take a general survey of the aorta, we shall find that it arises from the base of the left ventricle, ascends to beneath the dorso-lumbar column, curving backwards and downwards, and reaches the entrance to the pelvis, where it terminates by four branches. It furnishes, besides, about from 2 to 2½ inches from its origin, a secondary trunk, which soon divides into two new arteries, the right and largest of which gives off a particular trunk—the common origin of the two long vessels destined for the head.

This disposition permits us to recognize in the aorta seven principal sections:

1. The *aortic trunk*, or *common aorta*—the source of all the arteries, and giving origin to the anterior and posterior aorta. It only furnishes blood directly to the heart itself.

2. The *posterior aorta*—the real continuation of the common aorta—is distributed to the posterior moiety of the trunk and to the abdominal limbs; it terminates by a double bifurcation.

3. The *internal* and, 4, *external iliac arteries*—branches of this bifurcation which are almost entirely expended in the posterior limbs.

5. The *anterior aorta*—the smallest of the two trunks furnished by the common aorta—is chiefly destined for the anterior moiety of the trunk and the thoracic limbs.

6. The *axillary arteries*, or *brachial trunks*; these arise from the bifurcation of the preceding artery, and are continued by their terminal extremity into the fore limbs.

7. The *carotid arteries*, or arteries of the head; these emanate by a common trunk from the right brachial bifurcation.

Article I.—Aortic Trunk, or Common Aorta.

The point of departure for all the arteries carrying red blood, the common aorta, proceeds from the left ventricle by becoming continuous with the festooned fibrous zone which circumscribes the arterial orifice of that cavity. It passes upwards and a little forwards, bifurcating, after a course of 2 or 2½ inches, into the *anterior* and *posterior aortæ*.

Its volume, inferior to that of its two terminal branches, is not uniform; at its origin, and opposite the sigmoid valves, it presents (an enlargement—the *bulbus aortæ*—caused by) three dilatations, each corresponding to what is described as the *sinus of* the *aorta* (*sinus aortici*, *sinus Valsalvæ*).

Included, on the right side, in the crescent formed by the auricular mass; in relation, on the left side, with the pulmonary artery—which is joined to it by means of cellulo-adipose tissue traversed by the cardiac nerves—the common aorta forms, with the latter artery, a fasciculus enveloped by the visceral layer of the pericardium, which is reflected as a sheath around these two vessels.

Two collateral arteries are given off directly from the aorta—the *cardiac* or *coronary arteries*.

Cardiac or Coronary Arteries (Figs. 349, 350).

There are two *cardiac arteries*—a right and left—exclusively destined for the tissue of the heart.

Right Coronary Artery (Figs. 349, 1; 350, *l*).—This originates from the front and to the right of the aorta, at the free margin of the semilunar valves, and proceeds perpendicularly, or at a right angle, from the trunk, passing forwards to the right of the pulmonary artery, beneath the anterior auricle; then to the right and backwards, to reach the auriculo-ventricular groove, which it follows till near the origin of the right ventricular groove. Here it divides into two branches—one vertical, descending in this groove to the apex of the heart, which it bends round to the front, and anastomoses with an analogous branch of the left coronary artery; the other is horizontal, smaller than the first, and follows the original course of the artery in the auriculo-ventricular groove, also inosculating with the artery of the left side.

Left Coronary Artery (Fig. 349, 2).—This arises opposite the preceding, at the same angle of incidence, passes behind the pulmonary artery, and divides—under the left or posterior auricle—into two branches similar in every respect to those of the right artery. The vertical branch descends in the left perpendicular groove; the horizontal is lodged in the coronary groove; and both anastomose with the analogous branches of the opposite vessels.

From this arrangement, it results that the heart is surrounded by two arterial circles—a vertical, or ventricular, which has been compared to a meridian; and a horizontal, or auriculo-ventricular, analogous to an equatorial circle.

In their course—which is more or less tortuous—the coronary arteries throw out a considerable number of ramuscules, which enter the muscular tissue of the heart. The vertical circle gives off branches that are entirely ventricular; while from the horizontal circle come the superior or auricular, and inferior or ventricular branches. Among the latter there is one which, rising from the right artery—where it bends at an angle beneath the auricle—enters the substance of the right ventricle by passing round the pulmonary infundibulum; its ramifications anastomose with those of a similar branch from the left artery, and in this way establishes another communication between the two vessels.

Article II.—Posterior Aorta.

Course.—This artery (Fig. 349, 9) is a continuation of the aorta, which it nearly equals in volume, and from which it passes upwards and backwards, describing a curve the convexity of which is antero-superior, and which is known as the *arch of the aorta.* It thus reaches the left side of the inferior face of the spine, about the seventh dorsal vertebra, behind the posterior extremity of the longus colli musc'e, and is then carried directly backwards, following the bodies of the vertebræ, though a little to the left at first; it gradually inclines to the right, however, and reaches the median plane at the pillars of the diaphragm. Here it passes through the opening circumscribed by these two pillars (*hiatus aorticus*), enters the abdominal cavity, and extends to the entrance of the pelvis, under the spine, still preserving its median position. On reaching the last intervertebral articulation, the posterior aorta terminates by a double bifurcation, from which arise the *external and internal iliac arteries.*

Relations.—To facilitate the study of its connections, the posterior aorta may be divided into two sections—one *thoracic*, the other *abdominal*.

a. At its origin or arch, the *thoracic aorta* is crossed to the right by the trachea and œsophagus; on the opposite side, it is related to the pulmonary artery and the left lung. For the remainder of its extent, it is comprised between the two layers of the posterior mediastinum, and through these is in relation with the pulmonary lobes, which are fissured for its reception; this fissure is much deeper in the left than the right lung. Above, it is in contact with the bodies of the last twelve dorsal vertebræ, and is accompanied on the right by the large vena azygos and the thoracic duct; the latter is often carried to the left for the whole or a portion of its extent.

(Remak observed muscular fibres on the external face of the aortic arch and thoracic aorta in the Horse, Sheep, and Pig; the fasciculi they form are so large as to be visible to the naked eye.)

b. The *posterior* or *abdominal aorta*, enlaced by the abdominal nerves of the great sympathetic, is in relation, above, with the bodies of the lumbar vertebræ, the originating tendon of the diaphragmatic pillars, Pecquet's reservoir (*receptaculum chyli*), and the common inferior vertebral ligament; it passes above the pancreas and the peritoneum, the latter by its sublumbar layer covering the posterior two-thirds of the vessel. On the right, it is accompanied by the posterior vena cava, which perhaps it slightly pushes to the left of the median plane.

Collateral branches.—The arteries emanating from the posterior aorta during its long course, very naturally form two classes; some are designated *parietal*, because they are distributed to the parietes of the great splanchnic cavities; the others are the *visceral branches*, destined for the organs lodged in these cavities.

Among the *parietal branches*, may be noticed :—

1. The *intercostal arteries*, furnished by the thoracic aorta.

2. The *diaphragmatic* (or *phrenic*) *arteries*, the origin of which is placed on the limits of the two portions of the vessel.

3. The *lumbar arteries*, and the *middle sacral artery*, arising from the abdominal aorta.

The *visceral branches* are :—

1. The *broncho-œsophageal trunk*, emitted by the thoracic portion of the aorta.

2. The *cœliac axis*, *great* (or *anterior*) *mesenteric artery*, *small* (or *posterior*) *mesenteric artery*, *renal arteries*, *spermatic arteries*, and *small testicular* (or *artery of the cord*) or *uterine arteries*, which emerge from the abdominal portion.

Preparation of the posterior aorta and its collateral branches.—Immediately after injecting according to one of the modes recommended at p. 606, place the subject in the first position, the two posterior limbs being well extended backwards. Open the abdominal cavity, and remove from it the intestines in the manner already indicated. The tallow having become perfectly solidified during these necessary manipulations, dissection may be proceeded with at once. It is requisite, however, to remove the right and left walls of the thoracic cavity beforehand, by sawing through the last fourteen or fifteen ribs at six or seven inches from their superior extremity, and then separating them from the sternum by the saw, taking the precaution of detaching the peripheral insertion of the diaphragm. It is recommended to prepare, from before to behind, the various visceral branches of the vessel; first, the broncho-œsophageal artery; then the cœliac axis; next, the anterior mesenteric artery and the renal arteries, after spreading out the intestinal mass as in Fig. 283; and, lastly, the small mesenteric and testicular arteries, after arranging the intestines as in Fig. 366.

Parietal Branches of the Posterior Aorta.

1. Intercostal Arteries (Fig. 375).

The *intercostal arteries*, placed—as their name indicates—in the intervals of the ribs, number seventeen pairs.

Origin, Course, and Distribution.—The last thirteen arise from the thoracic aorta only; the first comes from the cervical artery; and the next three are furnished by a special branch of the dorsal artery.

The aortic intercostals emerge at a right angle from the superior plane of the trunk, on a level with the bodies of the dorsal vertebræ, and at regular intervals. Their origin is nearer that of the arteries on the opposite side as they are more anterior, the first two or three arising in pairs from a common trunk.

These aortic intercostals ascend to the vertebral bodies, beneath the pleura, in crossing the direction of the sympathetic nerve-trunk and—the arteries of the right side only—in addition, that of the vena azygos and the thoracic duct, to the superior extremity of the intercostal spaces, where those of both sides divide into two branches—the one *inferior*, or *proper intercostal;* the other *superior*, or *dorso-spinal.*

The inferior and superior branches of the first four intercostal arteries emanate solely from the trunk that furnishes them, and which is the superior cervical artery for the first intercostal, and the subcostal branch of the dorsal artery for the succeeding three.

Inferior or intercostal branch.—This branch, the most considerable of the two, placed at first beneath the pleura, then between the two intercostal muscles, is lodged, along with a satellite vein and nerve, in the furrow on the posterior face of the rib, and descends to the inferior extremity of the intercostal space, where it terminates in the following manner: the first twelve or thirteen branches anastomose with the intercostal ramifications of the internal thoracic artery and its asternal branch; the others are prolonged into the abdominal muscles, where their divisions communicate with those of the anterior and posterior abdominal arteries, as well as with the circumflex iliac.

In their course, these intercostal branches give arterioles to the pleuræ, the ribs, and the thoracic muscles, with the perforating ramuscules which cross these muscles to ramify in the skin and the panniculus carnosus, but which, of course, are absent where the pectoral wall is covered by the thoracic limb.

Superior or dorso-spinal branch.—This passes directly upwards to be distributed to the spinal muscles of the dorsal region and the integument covering them, after giving off, when passing the intervertebral foramen, a branch which enters the spinal canal by that opening, and is destined for the spinal cord and its envelopes. An auxiliary of the middle spinal artery, this branch will be studied at greater length when the cerebro-spinal artery is described.

Variations in origin.—Not unfrequently the first two pairs of aortic intercostal arteries proceed from a single trunk, thus giving rise to four branches; and this trunk is also often the source of these four intercostals and the bronchial and œsophageal arteries, when its volume is very considerable. It is much smaller when it only gives off the second pair of intercostals, which is sometimes the case.

2. Lumbar Arteries.

These are five or six in number, and do not differ in their general arrangement from the intercostal arteries; they having the same mode of origin, the same division into two branches, and the same distribution. The *superior*, or *lumbo-spinal* branch, is much larger than the inferior, and goes to the muscles and integuments of the lumbar region; it also furnishes a branch to the spinal cord. The *inferior branch* passes above the large and small psoas muscles, giving them numerous twigs, and extending to the muscular portions of the transverse and small oblique abdominal muscles, where their ramifications anastomose with those of the circumflex iliac artery.

The last, and sometimes also the second-last, lumbar artery arises from the internal iliac trunk; the others emerge directly from the iliac aorta.

3. Diaphragmatic (or Phrenic) Arteries.

These are two or three small vessels which spring from the aorta as it passes between the two pillars of the diaphragm, and are destined for that muscle. The left pillar receives a very insignificant branch, but the right has two, the most considerable of which is alone constant; it sometimes sends subpleural ramuscules to the right lung.

4. Middle Sacral (Sacra Media) Artery.

This vessel is often absent, and when it exists is very variable in size, though always extremely slender. It arises from the terminal extremity of the aorta, in the angle comprised between the two internal iliac arteries, and is carried to the inferior face of the sacrum, where it is expended in lateral ramifications which go to the periosteum. It has been thought necessary to notice this artery, as it attains a considerable volume in Man and some animals, and continues the aortic ramifications beneath the sacral portion of the vertebral column.

Visceral Branches of the Posterior Aorta.

1. Broncho-Œsophageal Artery (Fig. 318, m).

Destined for the lung, the visceral pleura, the mediastinum, and the œsophagus, this artery arises, not, as is generally said, in the concavity of the arch of the aorta, but opposite to it, and very near, but to the right of, the first pair of intercostals; often even in common with these arteries and with the second pair.[1] After leaving the aorta, it insinuates itself between that trunk and the œsophagus, and above the bifurcation of the trachea divides into branches, the *bronchial arteries*. In its short course, it gives off the two *œsophageal arteries* and a certain number of *innominate ramuscules*.

Bronchial Arteries.—The disposition of these two vessels is extremely simple; they enter the lung with the bronchi—one to the right, the other to the left—and there break up into arborescent ramifications that follow the air-tubes to the pulmonary lobules.

Œsophageal Arteries.—These two arteries are placed in the posterior mediastinum, one above, the other below the œsophagus, which they accompany for a short distance backwards, to the extremity of that canal.

[1] See Intercostals.

The *superior œsophageal artery*, much more voluminous than the inferior, inosculates with a branch of the gastric artery. In its course it gives descending branches to the œsophagus, and ascending ones to the mediastinum.

The *inferior œsophageal artery* also anastomoses with a branch of the gastric; most frequently with that noticed above. It likewises furnishes ascending and descending divisions; the latter, however, going to the mediastinum, and the former to the œsophagus.

Innominate Ramuscules.—The innominate ramuscules of the broncho-œsophageal trunk do not all proceed directly from it, there being always a certain number which emerge from the bronchial or œsophageal arteries. They are more particularly distributed to the trachea, to that portion of the œsophagus which is in contact with the posterior extremity of that tube, to the bronchial glands, the mediastinum, and the pulmonary pleura. Those destined for the latter form on the surface of the lung—along with the divisions of the pleural branch furnished by the gastric artery—a beautiful plexus.

2. Cœliac Artery (or Axis) (Fig. 365, 2).

This artery arises at a right angle from the inferior face of the aorta, immediately on the entrance of that vessel into the abdominal cavity. After a course from half to three-fourths of an inch at most, in the middle of the solar plexus, and beneath the superior face of the pancreas, this trunk separates into three branches—a middle, the *gastric artery;* a right, the *hepatic artery;* and a left, the *splenic artery.*

1. **Gastric Artery** (the *coronaria ventriculi* of Man) (Fig. 365, 3).—This artery descends on the large tuberosity of the stomach, extends to near the insertion of the œsophagus, and then divides into two branches—the *anterior* and *posterior gastric.* The first passes behind and to the right of the œsophagus, and crossing the small curvature of the stomach, gains the anterior face of that viscus, where it separates into flexuous and divergent branches that run beneath the serous membrane, and are carried more particularly towards the left *cul-de-sac* and around the cardia. The second vessel is distributed in the same manner to the posterior wall of the organ, but chiefly to the right sac.

Independently of these two arteries, the gastric trunk gives off a third and constant branch, which often comes from one of its two branches, and sometimes also from the cœliac axis itself, or from the splenic. This branch accompanies the œsophagus, along with the right pneumogastric, crosses the opening of the right pillar of the diaphragm to enter the pectoral cavity, and then divides into two branches, each of which anastomoses with one of the œsophageal arteries, and is then thrown over the posterior extremity of a pulmonary lobe, which it covers with a magnificent subpleural reticular arborization. This gastro-pulmonary artery often anastomoses with the superior œsophageal branch only, and goes exclusively to the right lung; for the left lung and the inferior œsophageal artery, in this case there is a special branch that emanates from the anterior gastric. It is not rare to meet with varieties of another kind, but of which it is not necessary to speak; inasmuch as in these pleural ramifications we find a disposition common to the whole arterial system—distribution almost invariable, origin very inconstant.

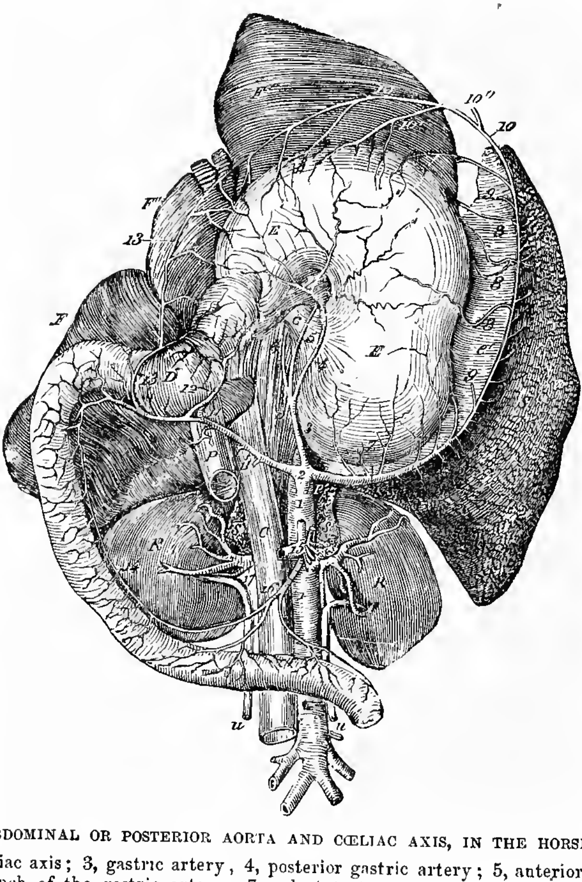
2. **Splenic Artery** (Fig. 365, 7).—The largest of the three branches of the cœliac axis, this artery is directed downwards and to the left, lying beside its satellite vein and the superior face of the left extremity of the pancreas. It

reaches the anterior fissure of the spleen, in turning round the cardiac extremity of the stomach, passes along the entire length of that fissure, and leaves it only near the point of the organ to throw itself into the great omentum, where it is named the *left gastro-omental artery* (or *gastro-epiploica sinistra*).

The splenic artery gives off, during its course, very numerous collateral branches. These are:

(1) External or *splenic* ramifications, which immediately enter the substance of the spleen (Fig. 365).

Fig. 365.



ABDOMINAL OR POSTERIOR AORTA AND CŒLIAC AXIS, IN THE HORSE.

1, Aorta; 2, cœliac axis; 3, gastric artery, 4, posterior gastric artery; 5, anterior gastric artery, 6, pleural branch of the gastric artery; 7, splenic artery; 8, gastric ramuscules; 9, omental ramuscules of the splenic artery; 10, left gastro-splenic artery; 10′, one of the gastric branches of that vessel; 11, hepatic artery; 12, pyloric artery; 13, right gastro-omental artery; 14, duodenal artery; 15, trunk of the great mesenteric; 16, first branch of the left fasciculus of that artery, communicating with the duodenal; 17, right renal artery. C, Œsophagus; E, stomach, lifted against the liver and diaphragm; D, duodenum; F, F′, F″, lobes of the liver; *f*, Spigelian lobe (caudate lobe), S, spleen; R, R, kidneys and supra-renal capsules, *s*, *s*; *u*, *u*, ureters; G, posterior vena cava; P, vena portæ; *p*, *p*, crura or pillars of the diaphragm.

(2) Internal or *gastric* ramifications, also called the *short vessels* (*vasa brevia*) in Man, which are comprised between the two layers of the gastro-splenic omentum, and go to the great curvature of the stomach, where they nearly always divide into two branches—one which ramifies on the anterior wall of the

viscus, the other on its posterior wall. These vessels inosculate with those sent to the membranes of the stomach by the proper gastric artery (Fig. 365, 8).

(3) Posterior or *omental* twigs of little importance, destined for the great omentum (Fig. 365, 9).

Left gastro-omental artery (Fig. 365, 10).—This artery follows the great curvature of the stomach to a distance varying with the state of repletion of that viscus, passing between the two layers of the omentum, and inosculating with the right gastro-omental artery. The branches it sends off on its track are descending or *omental*, and ascending or *gastric;* the latter being disposed exactly like the analogous branches emanating directly from the splenic artery.

3. **Hepatic Artery** (Fig. 365, 11).—Applied to the superior face of the pancreas, and encrusted, as it were, in the tissue of that gland—the anterior border of which it follows—the hepatic artery is directed from left to right, passes under the posterior vena cava, which it crosses obliquely, reaches the posterior fissure of the liver (*foramen of Winslow*), and enters it with the vena portæ to break up into several branches, the ultimate divisions carrying nutrient blood to the lobules of the liver.

Before reaching that organ, however, the hepatic artery furnishes the *pancreatic branches*, the *pyloric artery*, and the *right gastro-omental artery.*

Pancreatic arteries.—Irregular and very numerous, these branches are detached from the hepatic artery on its passage over the superior face of the pancreas, and plunge into the tissue of that gland, the arterial blood of which is chiefly derived from this source.

Pyloric artery.—This vessel arises at the dilatation towards the origin of the duodenum, before the hepatic artery enters the posterior fissure of the liver, and most frequently by a trunk common to it and the right gastro-omental artery. It passes towards the small curvature of the stomach, and sends off branches around the pylorus, which anastomose with the posterior gastric arteries and the right gastro-omental artery.

Right gastro-omental artery (*gastro-epiploica dextra*) (Fig. 365, 13).—This artery crosses the duodenal dilatation inferiorly and posteriorly, to place itself in the substance of the great omentum; in doing which it passes along the large curvature of the stomach, and anastomoses by inosculation with the left gastro-omental artery. In its course, it throws off omental and gastric branches, which are analogous to those emanating from the latter vessel. Before crossing the duodenum, it also emits a particular branch, designated in treatises on Veterinary Anatomy the *duodenal artery;* this is a somewhat considerable division, which follows the small curvature of the duodenum in the substance of the mesentery, and joins the first artery belonging to the left fasciculus of the great mesenteric, after furnishing some twigs to the pancreas, and numerous branches to the duodenum (Fig. 365, 14).

In terminating the description of the right gastro-omental artery, it may be remarked that the stomach—owing to the anastomoses uniting that vessel with the artery of the left side—is suspended, as it were, in a vertical arterial circle, formed by the splenic and left gastro-omental arteries on the one part, and the hepatic and right gastro-omental arteries on the other—a circle the concavity of which sends out on the stomach a great number of divisions that communicate with the arterial ramuscules proper to that viscus.

3. Anterior or Great Mesenteric Artery (Figs. 365, 366).

The *anterior mesenteric artery*, which almost entirely supplies the mass of intestines with blood, is as remarkable for its volume as for its complicated distribution. This complexity, together with that of the intestine itself, gives rise to some difficulty in the study of this vessel; but this may be averted by adopting the mode of description—as simple as it is methodical—resorted to in his lectures by Lecoq.

The anterior mesenteric arises at a right angle from the posterior aorta, at the renal arteries, and at 2 or 2½ inches behind the cœliac axis, from which it is separated by the pancreas; it is directed immediately downwards, enlaced by the anastomosing nerves of the solar plexus, and divides, after a course of from 1 to 1½[1] inches, into *three fasciculi* of branches, which are distinguished as *left*, *right*, and *anterior*. The *left fasciculus* goes to the small intestine; the *right* is distributed to the terminal portion of that intestine, the cæcum, and the first portion of the flexure formed by the large colon; the *anterior* is carried to the second portion of that flexure, and to the origin of the small colon. The order in which these three fasciculi have been indicated will also be that followed in their description; this has, as will be observed, the advantage of recalling to the memory the regular succession of the various parts of the intestine, and consequently the passage of the food in this important portion of the digestive canal.

A. Arteries of the Left Fasciculus (Fig. 366, 2).—These arteries number from fifteen to twenty, and are named the **arteries of the small intestine** (*vasa intestini tenuis*), because of their destination. All spring at once from the anterior mesenteric artery, either separately, or several in common, and pass between the two layers of the mesentery to gain the intestine. Before reaching the small curvature of that viscus, each divides into two branches, which go to meet corresponding branches from the neighbouring arteries, and to anastomose with them by inosculation; from this arrangement results a series of uninterrupted arterial arches, the convexity of which is downwards, and which exist for the whole length of the intestine, opposite, and in proximity to, its concavity. From the convexity of these arches emanate a multitude of branches that arrive at the inner curvature of the intestine, and the divisions of which pass to each of the faces of that viscus, to rejoin and anastomose on its great curvature. These divisions are situated beneath the peritoneum or in the muscular tunic, and send the majority of their ramuscules to the mucous tunic, which is therefore distinguished by its great vascularity—a feature common to all the hollow organs in the abdominal cavity.

Such is the general arrangement of the arteries of the small intestine; and it remains to indicate some of their special characters. These are as follows: 1. The longest arteries of the small intestine are the most posterior, as they follow the development of the mesentery, by which they are sustained. 2. The anterior arteries generally form two series of superposed arches, before sending their divisions to the intestine. 3. The first reaches the duodenum and anastomoses with the duodenal artery—a branch given off by the cœliac axis. 4. The last communicates with the ileo-cæcal artery—one of the branches of the right fasciculus.

[1] This trunk of the anterior mesenteric is usually, in old horses killed for dissection, the seat of a more or less voluminous aneurism, which sometimes extends to the artery placed at the origin of the branches of the right fasciculus, and it is not unfrequently met with in one or the other section of the anterior mesenteric artery.

B. Arteries of the Right Fasciculus.—The right fasciculus of the great mesenteric artery constitutes, at first, a single trunk some inches in length, which soon divides into four branches. These are as follows: the *ileo-cæcal artery*, the *two cæcal arteries*, and the *right* or *direct colic artery*.

Ileo-Cæcal Artery (Fig. 283, 3).—This vessel often has its origin from the internal cæcal artery. It is placed between the two layers of the mesentery, follows for a short distance, and in a retrograde manner, the ileo-cæcal portion of the small intestine, and wholly anastomoses with the last artery of the left fasciculus, after emitting a series of branches, which are distributed to the intestinal membranes.

Cæcal Arteries.—Distinguished into *internal* or *superior*, and *external* or *inferior*, these two arteries pass downward and a little to the right, towards the concavity of the cæcal flexure, embracing between them the terminal extremity of the small intestine, and lying at the middle part of the cæcal sac, following its direction.

The *superior*, or *internal cæcal artery*, is lodged in the most anterior of the fissures formed by the longitudinal bands of the cæcum, and extends beneath the serous tunic to nearly the point of the viscus, where it terminates by anastomosing with the external cæcal artery. The branches furnished by this artery during its course escape in a perpendicular direction, and distribute their ramifications on the walls of the cæcum (Fig. 283, 4).

The *external*, or *inferior cæcal artery*, passes between the cæcum and the origin of the colon, to descend along the first-named organ by placing itself in one of the external fissures, which is situated outwardly and posteriorly. Arriving at the point of the organ, this artery bends over it to anastomose with the vessel just described (Fig. 283, 7). It gives off on its track a series of transverse ramifications, similar to those of the latter artery; and besides these, a remarkable branch which may be named the *artery of the cæcal arch*. This branch is detached from the principal vessel near the origin of the colon, and ascends to the cæcal arch, following its concavity outwardly to pass forwards and downwards to the first portion of the large colon, where it disappears after following a certain course. The numerous collateral branches detached by this artery are sent to the walls of the latter portion of intestine, and the arch of the cæcum (Fig. 283, 6).

Right or Direct Colic Artery (Fig. 283, 7).—This is the largest of the branches composing the right fasciculus of the anterior mesenteric artery. Destined for the right portion of the flexure formed by the large colon, it lies immediately beside that viscus, beneath the peritoneal membrane, following it from its origin to its pelvic flexure, where the artery anastomoses by inosculation with the left colic or retrograde artery.

C. Arteries of the Anterior Fasciculus.—These are only two in number: the *left colic* or *retrograde*, and the *first artery of the small colon*, joined at their origin to an extremely short trunk.

Left Colic or Retrograde Artery (Fig. 283, 8).—This is carried to the left portion of the colic flexure, which it passes over, beneath the peritoneum, from the terminal extremity of the viscus to the pelvic flexure, where it meets the right artery; in this manner it follows a course the inverse of that pursued by the food, whence its name of *retrograde colic artery*.

Considered collectively, the *two colic arteries* represent a loop or flexure exactly like that formed by the large colon itself. They proceed parallel to each other and finish, after being slightly separated, by uniting to form a parabolic curve. This arterial loop occupies a deep position on the intestinal loop, being found on the inferior face of the first and fourth sections of the large colon, in the concavity of the flexure which gives rise to the supra-sternal and diaphragmatic curvatures, and on the superior plane of the second and third portions of the viscus.

A considerable number of collateral branches escape perpendicularly from this arterial loop, and pass into the membranes of the intestine; some of them establish a transverse communication between the two vessels.

First Artery of the Small or Floating Colon (Figs. 283, 9 ; 366, 4).—This branch, the calibre of which is often considerable, is inflected to the left, downwards and backwards, to be placed in the colic mesentery, very near the lesser curvature of the floating or small colon. It soon meets a branch of the posterior mesenteric artery, with which it anastomoses by inosculation.

D. Innominate Branches of the Great Mesentery.—These are the twigs sent to the lymphatic glands, supra-renal capsules, mesentery, and pancreas, the existence of which it is sufficient merely to mention. Among those supplied to the pancreas, there is one of somewhat considerable volume.

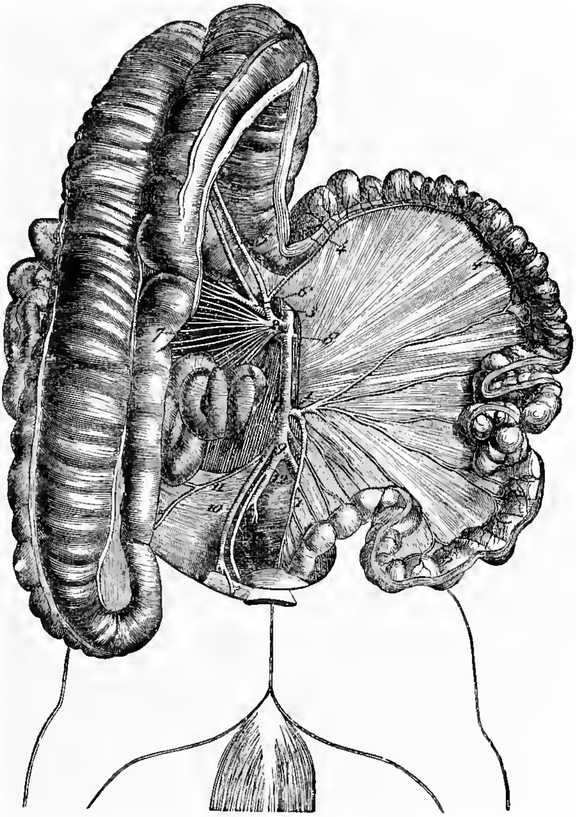
E. The Anastomoses of the Great Mesenteric Artery.—The multiplicity and calibre of these anastomoses assure, in the most favourable manner, the circulation of the blood in the intestinal mass, which, by reason of its great mobility, is exposed to displacements capable of inducing more or less extensive compression. Not only do these anastomoses unite the different branches destined to the same portion of the viscera—be it the small intestine, the cæcum, or the large colon ; but they also establish communications between the anterior mesenteric artery and the neighbouring trunks, which in case of need can maintain the circulation—as, for example, when the two intestinal arteries are completely obstructed. The blood from the cœliac axis can really pass from the duodenal artery into the branches of the left fasciculus of the anterior mesenteric ; then by the ileo-cæcal artery into the branches of the right fasciculus, and thence into the left colic artery, which, finally, transmits it to the first artery of the small colon, as well as to the arches of the mesenteric artery. The communication existing between the broncho-œsophageal and the cœliac trunks, through the medium of the œsophageal and gastric arteries, even allows a collateral circulation to be formed, which would be capable of supplementing the posterior aorta, supposing that vessel tied behind the trunk that distributes blood to the bronchi and œsophagus.

4. Posterior or Small Mesenteric Artery (Fig. 366).

This artery carries blood to the small colon and rectum, and arises at a right angle from the inferior face of the posterior aorta, from 4½ to 6 inches behind the anterior mesenteric. It descends between the two layers of the colic mesentery, and is soon inflected back in describing a curve upwards, to pass above the rectum ; when near the anus, its terminal divisions enter the walls of that intestine.

In its course this artery gives off, at pretty regular intervals, thirteen or fourteen branches, the foremost of which are the largest and longest ; they originate from the convexity of the artery—that is from below, and either singly or in clusters ; the latter disposition is the most common for the first four or five. They descend into the mesentery, and arrive near the superior curvature of the intestine, where they are disposed in the following manner: The first seven or eight bifurcate, and form arches like those of the arteries supplying the small intestine, differing from them only in being nearer the small curvature of the colon; the other branches, which are destined for the terminal part of that

Fig. 366.



DISTRIBUTION OF THE POSTERIOR OR SMALL MESENTERIC ARTERY. THE SMALL COLON WITH ITS MESENTERY IS SPREAD OUT AND THE SMALL INTESTINE THROWN BACK TO THE RIGHT, UNDER THE DOUBLE COLON.

1, Trunk of the posterior mesenteric artery; 2, anterior mesenteric artery; 3, its anterior fasciculus; 4, first artery of the small colon, forming part of that fasciculus; 5, retrograde colic artery; 6, right fasciculus of the anterior mesenteric; 7, branches of the left fasciculus; 8, renal artery, 9, terminal extremity of the aorta; 10, external iliac artery; 11, circumflex iliac artery; 12, internal iliac artery.

viscus and the rectum, ramify in the intestinal membranes without having previously formed any arches.

The anterior ramuscule of the first branch anastomoses directly with the artery sent to the small colon by the anterior mesenteric, and from this anastomosis results the first colic arterial arch.

5. Renal or Emulgent Arteries (Figs. 338, 2; 365, 17).

These are two arteries—one for each kidney—detached laterally, and at a right angle, from the abdominal aorta, near the anterior mesenteric artery; passing outwards to the internal border of these organs, each divides into several branches, which enter the gland either by its hilus or by its inferior face. Reaching the interior of the kidney, these branches subdivide, and form a net-work of large vessels placed on the limit between the cortical and medullary portions, from which a multitude of ramuscules are given off, and pass almost exclusively into the tissue of the cortical portion (see the description of the *Kidneys*).

The right renal artery, longer than the left, passes between the small psoas muscle and the posterior vena cava, to reach the right kidney. Both arteries are in relation with the posterior extremity of the supra-renal capsules.

Remarkable for their relatively enormous volume, when compared with that of the glands receiving them, these arteries, before penetrating the proper tissue of the kidneys, give off only a few unimportant ramuscules, the principal of which proceed to the supra-renal capsules (Fig. 365). Other twigs from the anterior mesenteric artery, or even from the aorta itself, also supply these small bodies. It is not unusual to find the kidneys receiving vessels from the arteries in their vicinity. Thus, we have seen an artery from the external iliac pass into a kidney by its lower face; and we have also observed an artery, detached from the aorta along with the anterior mesenteric, enter the kidney by its anterior border.

6. Spermatic Arteries.

These arteries differ in the male and female; in the male they are also named the *great testicular arteries;* in the female they are exclusively designated as the *utero-ovarian arteries*.

Spermatic or Great Testicular Artery (Fig. 338, 3).—This arises close to the posterior mesenteric artery, either before, behind, or to one side of it, but rarely on the same level as the artery of the opposite side; it is then directed backwards and downwards, sustained, with its satellite vein, in a particular fold of peritoneum, and reaches the entrance to the internal abdominal ring, into which it is seen to pass with the other portions of the spermatic cord, and to descend on the testicle by forming remarkable flexuosities, which are united into an elongated mass. Arrived within the head of the epididymis, this artery insinuates itself beneath the tunica albuginea—becomes encrusted, as it were, in its substance—and successively passes round the superior border, posterior extremity, and the inferior border and anterior extremity of the testicle. In this course it is very sinuous, and detaches at a right angle a large number of equally flexuous branches, which creep over the faces of the organ while sending numerous ramuscules into its structure. The epididymis also receives its blood by this artery.

Utero-ovarian Artery.—The origin of this vessel is the same as that of the preceding artery. It is placed between the two layers of the broad ligament, and soon bifurcates into the *ovarian* and *uterine arteries*. The *ovarian* branch describes numerous flexuosities, like the corresponding artery in the male, and comports itself on the ovary in the same manner as the latter vessel does on the testicle. The *uterine* branch passes to the cornu of the uterus, where its divisions anastomose with the proper uterine artery.

7. Small Testicular Arteries (Male). Uterine Arteries (Female).

Small Testicular Artery (Cremasteric Artery, Artery of the Cord).—A pair, like the spermatic artery, this vessel is very slender, and originates either from the aorta between the internal and external iliacs, or from the latter, near its commencement. The last being the most common, it is usual to describe it as a collateral branch of the external iliac trunk. We have regarded it as an artery emanating directly from the posterior aorta, in order to include its description with that of the spermatic and the utero-ovarian arteries.

Whatever may be its mode of origin, it gains entrance to the inguinal canal with the spermatic vessels, to be distributed to the various parts constituting the spermatic cord. Before penetrating the substance of this cord, it gives off several ramuscules to the peritoneum, iliac glands, ureter, and vas deferens.

Uterine Artery.—This has the same point of origin as the preceding—its analogue—but differs from it in its larger volume. It is placed between the two layers of the broad ligament, and soon divides into two branches—*ovarian* and *uterine*. The *ovarian* branch is flexuous, like the corresponding artery in the male, and comports itself on the ovary as that vessel does on the testicle. The *uterine* branch passes to the cornu of the uterus, where its divisions anastomose with the uterine artery proper.

Differential Characters in the Posterior Aorta and its Collateral Branches in the other Animals.

Posterior Aorta in Ruminants.

The artery pursues the same course as in Solipeds, and also terminates by four branches, towards the entrance to the pelvic cavity.

Parietal Branches.—The *intercostal arteries* only differ from those of the Horse in their number; as but twelve are met with, of which eight or nine are furnished by the posterior aorta alone.

The *lumbar* and *diaphragmatic branches* are absolutely identical, in their disposition, with the analogous arteries in Solipeds.

The *middle sacral artery* is more considerable in volume, particularly in the **Sheep** and **Goat**. This will be referred to hereafter (see *Internal iliac artery of Ruminants*).

Visceral Branches *Broncho-œsophageal trunk*.—This offers nothing particular.

Cœliac axis (Fig. 367, 1).—This artery descends on the rumen, a little behind the insertion of the œsophagus, is directed to the right, and divides near the omasum into two terminal branches—the *superior* and *inferior arteries of the omasum and abomasum.*

The collateral branches given off from this trunk are:—

1. Several *diaphragmatic orteries.*
2. The *splenic artery*, almost exclusively destined for the spleen (Fig. 367, 8).
3. The *superior artery of the rumen*, always arising from a very short trunk common to it and the preceding vessel, is carried backward to the superior face of the rumen, and from this descends between the two conical vesicæ, to anastomose with the artery of the inferior face of the viscus (Fig. 367, 2).
4. The *inferior artery of the rumen*, which is insinuated between the two anterior *culs-de-sac*, and afterwards runs along the inferior face of the organ, passing towards the notch separating the two conical vesicæ, to meet the superior vessels (Fig. 367, 3).
5. The *artery of the reticulum*, has usually a common origin with the inferior artery of the rumen, and passes forward on the left of the œsophagus, to be divided, near the insertion of that conduit, into two branches—one, the *superior*, inclines to the right on the small curvature of the viscus (Fig. 367, 5); the other, the *inferior*, occupying the fissure separating the great curvature of the reticulum from the right sac of the rumen, and giving to the latter organ a great number of branches (Fig. 367, 4).
6. The *hepatic artery*, which is not only distributed to the liver, but also furnishes a branch for the gall-bladder, and a duodenal artery breaking up into two branches—the posterior branch forming with the first artery of the small intestine an arching anastomosis; the anterior communicating with the superior artery of the omasum and abomasum. This hepatic artery always originates between the trunk common to the splenic artery and the superior branch of the rumen, and that which gives off the superior branch of the same viscus and the artery of the reticulum.

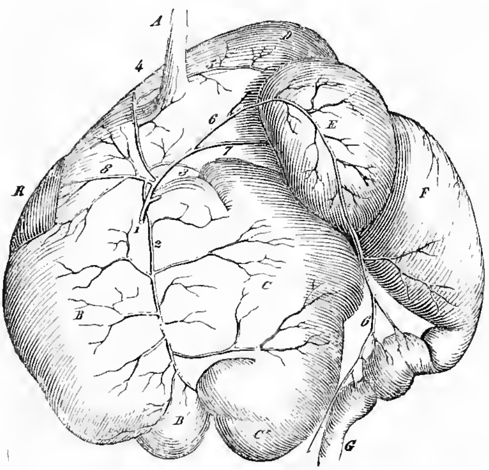
The terminal branches of the cœliac artery comport themselves as follows:—

1. The *superior artery of the omasum and abomasum* passes successively to the great curvature of the first of these reservoirs, and to the concave curvature of the second; then it goes beyond the pylorus to unite with the duodenal branch of the hepatic artery by inosculation (Fig. 367, 6).

2. The *inferior artery of the omasum and abomasum*, on the contrary, passes at first over the small curvature of the omasum, afterwards the great curvature of the abomasum, and disappears in the omentum, to which on its course it furnishes a great number of branches (Fig. 367, 7).

In small Ruminants, the distribution of the arteries of the cœliac axis presents some modifications. We will cite the principal, which belong to the mode of origin of the two branches destined for the reticulum—these branches form two particular vessels which arise singly from the cœliac axis: the inferior artery at the same point as the superior artery of the rumen, the superior towards the terminal bifurcation of the axis.

Fig. 367.



ARTERIES OF THE STOMACH IN RUMINANTS.

1, Cœliac axis; 2, superior artery of the rumen; 3, inferior artery of the rumen; 4, inferior artery of the reticulum; 5, superior artery of the reticulum; 6, superior artery of the omasum and abomasum; 7, inferior artery of ditto; 8, splenic artery. A, Œsophagus; B, left sac of the rumen; B′, left conical vesica; C, right sac of the rumen; C′, right conical vesica; D, reticulum; E, omasum; F, abomasum; G, duodenum; R, spleen.

Anterior mesenteric artery.—Its origin approaches very closely that of the cœliac axis. After a course of from 6 to 8 inches, it divides into two branches—an anterior and a posterior. The first, for the small intestine, creeps above it, between the two layers of the mesentery, and passes backward by describing a curve which gives off from its convexity—that is, below—a great number of branches, analogous in their mode of termination to the arteries of the small intestine in the Horse. The posterior branch goes to the large intestine, where it separates into two principal branches: one which passes to the colon, its divisions crossing to the right, to behind and below, the convolutions described by that viscus; another which reaches the concave curvature of the cæcum, and anastomoses by an arch with the terminal extremity of the parent-branch of the arteries supplying the small intestine.

Posterior mesenteric artery.—Very short and narrow.

Renal, spermatic, and small spermatic arteries.—These do not differ in their essential disposition from the analogous vessels in Solipeds.

2. Posterior Aorta in the Pig.

With the exception of the mesenteric vessels, the distribution of which resembles that already indicated for Ruminants, and with the exception, also, of the middle sacral artery, which will be alluded to when describing the internal iliac arteries, all the branches given off by the posterior aorta comport themselves almost as in the Horse.

3. Posterior Aorta in Carnivora.

In these animals, as well as in the Pig, the denomination of posterior aorta is not justifiable, because the arteries of the head and thoracic limbs spring directly from the aortic arch.

The branches of the aorta are distinguished as parietal and visceral.

A. Parietal Branches.—Beyond the fourth space, the *intercostal arteries* are furnished by the aorta; the first is voluminous, and throws off some considerable filaments to the muscles of the withers. The first two *lumbar arteries* arise from the thoracic portion of the aorta, because of the very backward insertion of the diaphragm; the third is detached between the two pillars of that muscle. In the abdominal cavity, close to the anterior mesenteric, the aorta gives off a branch that soon divides into two: one is *diaphragmatic*, and descends on the posterior face of that muscle; the other reaches the sublumbar region, passes over the psoas muscle, and traverses the abdominal wall in the vicinity of the transverse processes of the lumbar vertebræ. We will speak presently of the *middle sacral.*

B. VISCERAL BRANCHES.—I have not found in the Dog any special *bronchial arteries;* but there are four or five *œsophageal arteries* that arise from different points of the thoracic aorta; they descend into the mediastinum, to the right and left of the œsophagus, to which they are distributed. They furnish branches that accompany the bronchi and enter the lungs.

The *cœliac axis* is again divided into three branches, as follows: The *gastric,* or *stomachic coronary artery,* does not divide into two branches (anterior and posterior gastric) as in Solipeds. Near its origin it furnishes a pancreatic branch; then it expends itself in a great number of filaments that are spread over the posterior face and great tuberosity of the stomach, or over its anterior face after crossing the small curvature.

The *splenic artery* reaches the spleen at the middle of its upper border. It gives on its course: 1. A splenic branch that enters the upper extremity of that organ. 2. The left gastro-omental. The *hepatic artery* provides the principal hepatic vessel at the posterior fissure of the liver; it is then continued by the right gastro-omental artery. On the duodenum, the latter gives origin to the pyloric and the pancreatico-duodenal branches; the latter is voluminous, is lodged in the substance of the pancreas, and anastomoses by its last filaments with the anterior mesenteric.

The *anterior mesenteric artery* arises in the vicinity of the cœliac axis; it forms a curve with the convexity backward, and anastomoses by its extremity with the pancreatico-duodenal branch of the hepatic. From its convexity are detached several filaments (filaments to the small intestine), that form arches towards the smaller curvature of that viscus. Behind, and at a short distance from its origin, it gives a branch to the cæcum and branches to the colon; the latter are sometimes large.

The *posterior mesenteric* commences near the termination of the aorta, and divides into two branches—one passing forward, the other backward; they form the hæmorrhoidal vessels (see Fig. 290).

There is nothing special to note with regard to the renal and spermatic arteries.

COMPARISON OF THE AORTA OF MAN WITH THAT OF ANIMALS.

The aorta in Man offers the same general arrangement as in the Carnivora, the trunk being inflected across, to be placed along the body of the dorsal and first lumbar vertebræ, where it terminates in the iliac vessels.

It furnishes the *coronary arteries,* the arteries of the head and thoracic limbs—which will be noticed hereafter; and the parietal and visceral branches to the chest and abdomen. At first these are the *intercostals,* beyond the third space; the *diaphragmatic arteries,* superior and inferior according as they occupy one or other face of the diaphragm; and, lastly, the *lumbar arteries.*

Among the visceral branches are distinguished: 1. The *bronchial arteries,* two in number; the left arises from the concavity of the aortic arch, and enters the lungs with the left bronchus; the right originates alone or in common with the preceding, and enters on the right bronchus. 2. The *œsophageal arteries,* disposed somewhat as in the Dog. 3. The *cœliac trunk,* the distribution of which is nearly identical with that of the Carnivora. 4. The *superior* or *great mesenteric,* disposed in arches as in the Dog (see Fig. 292, 9). Its last branches pass to the cæcum, and the ascending and origin of the transverse portion of the colon. 5. The *inferior* or *small mesenteric,* which arises from 1½ to 2 inches from the bifurcation of the aorta; this artery descends into the meso-colon, and terminates on the sides of the rectum by the hæmorrhoidal vessels; to the left, they emit branches to the large intestine; the first ascend along the descending colon, and anastomose on the transverse colon with the right colic branch of the superior mesenteric. 6. The *renal* and *capsular arteries,* which do not offer important differences. 7. Lastly, the *spermatic arteries,* which are remarkable for the length of their course, commencing, as they do, at the aorta, a short distance below the renal vessels.

ARTICLE III.—INTERNAL ILIAC ARTERIES, OR PELVIC TRUNKS (Figs. 338, 368, 370).

The two internal iliac arteries represent the middle or internal branches of the quadrifurcation formed by the posterior aorta at its terminal extremity.

Extending from the body of the last lumbar vertebra, to near the terminal insertion of the small psoas muscle, in an oblique direction downwards, outwards, and backwards, the arteries are related : in front, with the trunks of the common iliac veins, which separate them from the external iliacs ; inwards, to the peritoneum ; above and outwards, to the sacro-iliac articulation and to the ilium.

In its course, the internal iliac artery emits the following branches : the *umbilical artery*, *artery of the bulb*, *ileo-lumbar, gluteal*, and *subsacral arteries*. At its terminal extremity, it is divided into two branches which ride on the superior border of the tendon belonging to the small psoas muscle—the one within, the other without that tendon. The first is the *obturator artery*, the second the *ileo-femoral artery*. All these branches will be studied in the order of their enumeration.

Preparation of the internal iliac artery.—Place the subject in the first position ; remove one of the posterior limbs, leaving the rectum and bladder in the pelvis, and slightly inflating the latter organ. Dissect, on the side from which the limb has been removed, the origin and visceral ramifications of the branches furnished by the trunk of the artery. Follow, on the opposite side, the ramifications given off by these branches to the muscles. To conveniently prepare the coccygeal arteries, it is necessary, after removing the great sciatic ligament and dissecting the internal artery of the bulb along with the subsacral trunk, to raise up the rectum and bladder by means of the chain-hooks.

1. Umbilical Artery (Figs. 368, 5 ; 370, 3).

This artery forms a considerable vessel during fœtal life, and carries the blood of the fœtus to the placenta ; it will be described in detail in the anatomy of the fœtus.

In the adult it is almost entirely obliterated, appearing only as a fibrous cord extending from the internal iliac artery to the fundus of the bladder, and placed at the free margin of the lateral serous fold detached from the fundus of that organ. This cord throws off on its track one or more *vesical branches*, beyond which its canal altogether disappears. These vesical branches also—though very rarely—come from the internal pudic artery ; in which case the obliteration of the umbilical artery is complete.

2. Internal Pudic Artery, or Artery of the Bulb (Figs. 368, 16 ; 370, 4)

This vessel differs in its distribution in the male and female.

Internal Pudic Artery in the Male.—It proceeds from the internal iliac, near the origin of that vessel, by a trunk common to it and the umbilical artery ; it is then directed backwards, following the superior border of the pyriformis muscle, and placed either without or within the texture of the sacro-sciatic ligament. Arrived at the neck of the bladder, it enters the pelvic cavity, lying beside the prostate and Cowper's glands, and is finally inflected downwards, passing round the ischial arch to reach the bulb of the urethra.

In its progress it furnishes :

1. Insignificant ramuscules to the muscle adjoining the sacro-sciatic ligament.

2. *The vesico-prostatic artery* (Figs. 338, 8 ; 368, 17). This is a branch constant in its distribution, but variable in its origin. Destined to supply the prostate gland, vesiculæ seminales, the pelvic dilatation of the vas deferens and the canal itself, as well as the bladder, it usually commences near the prostate gland, and passes backwards, in a flexuous manner, on the vesiculæ seminales and the vas deferens.

3. Slender ramifications for the pelvic portion of the urethral canal, Cowper's glands, the anus, and the erector penis muscle.

The terminal extremity of the vessel is insinuated beneath the accelerator urinæ muscle, and immediately divides into a multitude of ramuscules which enter the erectile tissue of the urethral bulb, where they comport themselves as in all tissues of this kind.

Varieties.—It is not rare to see this artery detach—before reaching Cowper's gland—the *cavernous artery*, which then passes round the ischial arch along with the nerve of the penis. Sometimes it only gives off the *posterior dorsal artery of the penis*—a branch of the cavernous.

Internal Pudic Artery in the Female. (Fig. 370, 4.)—This artery terminates, towards the vagina, by rectal, vulvar, vaginal, and bulbar branches; the latter are for the bulb of the vagina. As in the male, it does not give off more than one important branch on its course; this—the *vaginal artery* (Fig. 370, 5)—is analogous in every respect to the vesico-prostatic artery; its terminal divisions go not only to the middle portion of the vagina, but also to the body of the uterus, where they anastomose largely with the branches of the uterine artery, and even pass to the bladder and rectum.

The internal pudic artery of the female, as in the male, is liable to numerous variations. It may furnish the cavernous artery, or only the dorsal artery of the clitoris. We have seen the vaginal artery come from the umbilical.

3. Lateral Sacral or Subsacral Artery (Figs. 368, 12; 370, 6).

Rising from the inner side of the internal iliac artery, at, or a little behind the lumbo-sacral articulation, lying above the peritoneum, and beneath the sacral foramina and the large nerves passing through them, this vessel is directed backwards, and arrives near the posterior extremity of the sacrum, where it ends in two branches: the *ischiatic* and *lateral coccygeal arteries*, to which must be added the *middle coccygeal artery*, usually given off by the vessel of the right side.

Collateral Branches.—The lateral sacral artery sends off on its course several insignificant ramuscules destined for the neighbouring parts, and four spinal branches which enter the spinal canal by the inferior sacral foramina, and leave it again by the superior, after throwing off some divisions to the posterior extremity of the spinal cord and the cauda equina nerves; these branches ramify in the muscles lying along the sacral spine.

Terminal Branches.—1. **Ischiatic Artery.**—It crosses the sacro-sciatic ligament, to place itself under the superior extremity of the posterior portion of the superficial gluteus, passes backwards and downwards, and divides into several branches which descend into the substance of the semimembranosus and semitendinosis muscles, to beneath the ischial tuberosity. These branches anastomose, by their extremities, with the ascending branches from the femoro-popliteal, as well as with the divisions of the obturator and deep femoral arteries.

2. **Lateral Coccygeal Artery.**—This vessel represents the continuation of the lateral sacral artery, though not by its volume—which is much less than that of the ischiatic artery—but in its direction. It proceeds from before to behind, for the whole length of the coccyx, between the rudimentary vertebræ of that region and the compressor coccygis, gradually diminishing in volume, and

detaching on its course a series of collateral ramuscules, which are expended in the muscles and integuments of the tail.

There has been described a superior lateral artery, a branch of the preceding, and which passes between the erector coccygis and the superior face of the coccygeal vertebræ; but this artery never exists: the superior coccygeal muscle receives its blood by branches analogous to the spinal branches of the intercostal, lumbar, and sacral arteries, and which emanate from the lateral coccygeal artery at each of the vertebral bodies.

3. **Middle Coccygeal Artery.**—The origin of this vessel is liable to numerous variations. Ordinarily, it is detached from the right lateral sacral artery, in common with the lateral coccygeal of the same side. At other times, it escapes from the lateral at 5 or 6 inches from its origin. In a specimen now before us, it arises nearly from the middle of the lateral sacral artery. And it may also proceed from either the left sacral or the corresponding lateral coccygeal artery.

Whatever may be its point of emergence, this vessel is placed beneath the inferior face of the coccygeal vertebræ, between the two compressores coccygis, crosses the suspensory ligament of the rectum, and extends to the extremity of the coccyx, distributing ramusculcs to right and left, and even downwards.

4. Ilio-lumbar or Ilio-muscular Artery (Figs. 368, 14; 370, 8).

Immediately after clearing the inferior face of the lateral angle of the sacrum—and even often before—the internal iliac artery gives off from its external side, and at a right angle, the ilio-lumbar artery, which passes directly outwards, behind the sacro-iliac articulation, between the iliacus muscle and the bony surface covered by it, and emits divisions that proceed to the above-named articulation, as well as to the muscles of the sublumbar region. Near the angle of the haunch, it terminates in several branches, which bend upwards on the external border of the ilium, to penetrate the principal gluteal muscle, or the tensor vaginæ femoris.

5. Gluteal Artery (Figs. 368, 13; 370, 7).

This, the most voluminous of the branches emanating from the internal iliac, arises opposite the preceding, and from $\frac{8}{10}$ of an inch to $1\frac{1}{5}$ inches behind the lateral sacral. It is immediately reflected on the internal border of the ilium, and emerges from the pelvis by the great sacro-sciatic foramen, along with the anterior gluteal nerves, dividing into several branches which ramify in the texture of the great and small gluteal muscles.

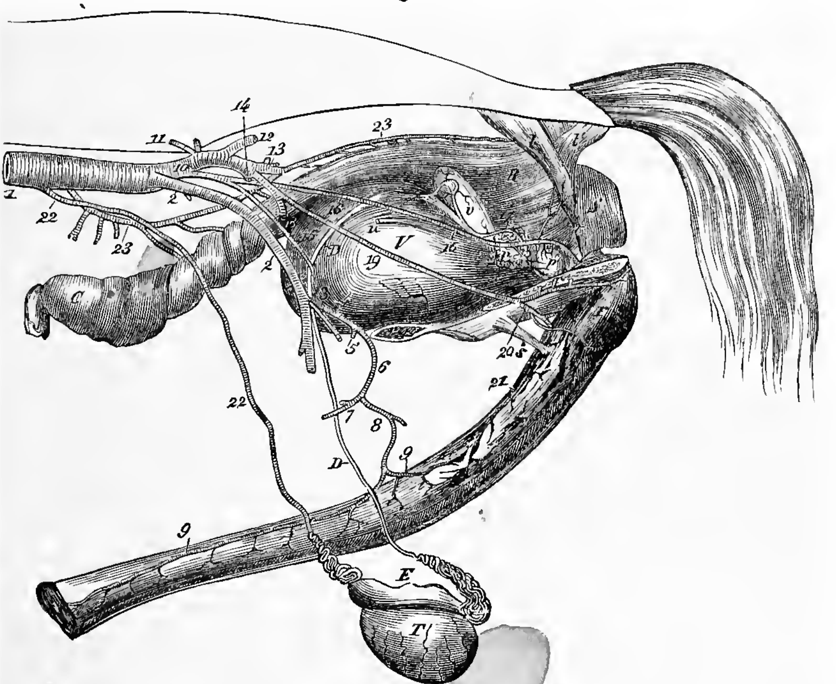
6. Obturator Artery (Figs. 368, 19; 370, 10).

This vessel, the origin of which has been already indicated, directs its course backward and downward, accompanied by a satellite vein and nerve, passes between the peritoneum and ilium in following the inferior border of the pyriformis muscle, and finally insinuates itself beneath that muscle to make its exit from the pelvis by creeping through the obturator foramen, after furnishing a constant vesical twig. Placed between the external obturator muscle and the inferior face of the ischium, it separates into several branches, the majority of which descend into the internal crural and ischio-tibial muscles, anastomosing with the ultimate divisions of the ischiatic and deep femoral arteries. Among these branches there are two or three which go to the roots of the penis, and enter the erectile tissue of the corpus cavernosum ; one of them, more important than the others by its volume, is designated the *artery of the corpus cavernosum.*

The obturator artery sometimes arises from the external iliac.

Artery of the Corpus Cavernosum (Fig. 368, 20).—This vessel passes on the inferior face of the ischium, backwards and inwards, reaches the crus penis,

Fig. 368.



LATERAL VIEW OF THE GENITO-URINARY ORGANS IN THE MALE.

1, Abdominal aorta ; 2, external iliac artery ; 3, common origin of the prepubic and deep femoral arteries ; 4, prepubic artery ; 5, posterior abdominal artery ; 6, external pudic artery ; 7, subcutaneous abdominal artery ; 8, anterior dorsal artery of the penis ; 9, 9, anterior and posterior branches of that artery ; 10, internal iliac artery ; 11, last lumbar artery ; 12, subsacral artery ; 13, gluteal artery ; 14, iliaco-muscular artery ; 15, umbilical artery ; 16, internal pudic artery ; 17, its vesico-prostatic branch ; 18, iliaco-femoral artery ; 19, obturator artery ; 20, artery of the corpus cavernosum ; 21, posterior dorsal artery of the penis—a branch of the preceding ; 22, spermatic artery ; 23, posterior mesenteric artery. C, Termination of the small colon ; R, rectum ; S, sphincter of the anus ; *l*, suspensory ligament of the penis ; *l'*, suspensory ligament of the rectum ; V, bladder ; *u*, ureter ; T, testicle ; E, epididymis ; D, deferent canal , *v*, vesiculæ seminales ; P, prostate ; *p*, Cowper's gland ; *r*, crus penis ; *s*, ligament of the corpus cavernosum.

and pierces it by several branches, after supplying some muscular divisions and the *posterior dorsal artery of the penis.*

The latter is situated on the dorsal margin of the penis, passes forward between the two ligaments attaching that organ to the symphysis pubis, and proceeds to anastomose with the posterior branch of the anterior dorsal artery (Fig. 368, 21).

7. Iliaco-femoral Artery (Figs. 368, 18 ; 370, 9).

Noticed as one of the terminal branches of the pelvic trunk, the iliaco-femoral artery only exists as a vessel of a certain volume in Solipeds. In other animals, as in Man, it is merely an insignificant and innominate branch of the obturator artery. It proceeds outside the tendon of the small psoas muscle, between the iliacus and the neck of the ilium, which it passes round obliquely, above the origin of the rectus femoris muscle, to descend on the external side of the latter, and plunge into the mass of the patellar muscles, entering them between the rectus femoris and vastus externus, after sending some branches to the psoas and gluteal muscles, and tensor vaginæ femoris.

Differential Characters in the Internal Iliac Arteries of the other Animals.

1. Internal Iliac Arteries of Ruminants.

The terminal extremity of the aorta, after giving off the external iliac arteries, bifurcates to constitute the internal iliacs, and in the angle of bifurcation throws out a very large branch —the *sacra media*—from which emanate the arteries of the tail. This, however, is not the only important peculiarity to be noted in the disposition of the pelvic arteries. The internal iliac artery emits at its origin a very short, but very large branch, which divides to form the *umbilical artery*, and an enormous *uterine artery*, that supplants, to a great extent, the utero-ovarian artery; it is then directed backwards, on the internal face of the great sacro-sciatic ligament, crossing the direction of the lumbo-sacral plexus. In its course it furnishes branches resembling the *iliaco-muscular*, the *gluteal*, and the *ischiatic*, and is continued about the middle of the pelvis by the *internal pudic artery*, which terminates by forming the *dorsal artery of the clitoris*, after distributing branches to the rectum and the genito-urinary organs lodged in the pelvic cavity.

It will be seen from this description—which refers only to female animals, but is easily applicable to males—that no mention is made of an *iliaco-femoral* or *obturator artery*. This is because these two vessels are entirely absent in the Sheep, and the last, though present in the larger Ruminants, is yet in a very rudimentary state, both being supplemented by the deep femoral, the dimensions of which are considerable. Neither is the *lateral sacral artery* described, as it is also absent, its *ischiatic branch* coming directly from the pelvic trunk, and its *coccygeal divisions* being supplied by the middle sacral artery.

2. Internal Iliac Arteries of the Pig.

Two single branches, originating one above the other, arise from the extremity of the aorta, between the two internal iliac arteries; one divides almost at once into two lateral branches, which go to right and left beneath the iliacus, and are the representatives of the *iliaco-muscular arteries* of the Horse; the other, or *sacra media*, placed in the middle line, proceeds backwards on the inferior face of the os sacrum, and constitutes the *coccygeal arteries* after giving off, at about 1½ inches from its origin, two lateral branches, traces of the *lateral sacral arteries*, which furnish the spinal ramuscules of the sacral region.

The *internal iliac artery*, near its origin, sends off the *umbilical artery*, is directed back towards the sacro-sciatic foramen, there detaches gluteal branches, and is prolonged beyond the foramen to the external surface of the sacro-sciatic ligament, in forming the *internal pudic artery*.

The latter emits, before leaving the pelvic cavity, a long *hæmorrhoidal artery*, that creeps back by the side of the rectum, to be distributed to the posterior extremity of that intestine and the adjoining genito-urinary organs. Outside the pelvis, it gives off some gluteal branches, the most considerable and posterior of which represent the *ischiatic artery* of Solipeds. It then re-enters the cavity of the pelvis, and terminates at the base of the penis by forming the *cavernous* and *dorsal arteries* of that organ.

3. Internal Iliac Arteries of Carnivora.

The internal iliac arteries in the Carnivora result from the bifurcation of an arterial trunk that prolongs the aorta beyond the origin of the external iliacs, as far as the first intersacral articulation.

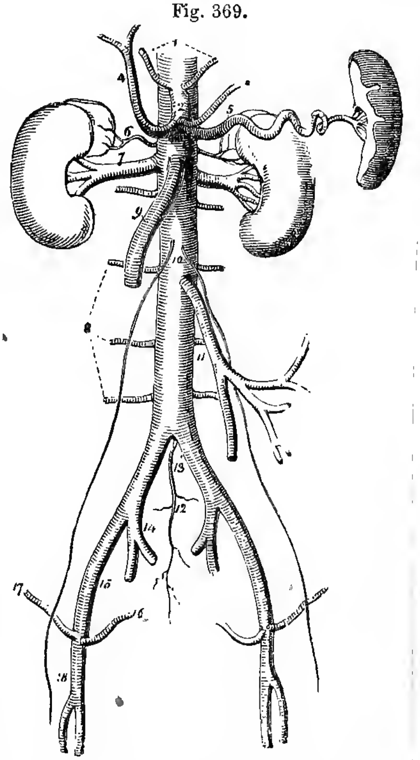
This pelvic trunk at first gives off the *umbilical artery*, which is remarkable for its small calibre, and the flexuosities it describes before reaching the bladder.

Then the internal iliac artery courses for 1 or 1½ inches behind, and to the inside of, the pelvi-crural venous trunk, dividing into two branches at the entrance to the pelvis.

One of these branches goes towards the viscera contained in the pelvic cavity; this is the *internal pudic artery*. It passes backwards, turns round the ischial arch, and terminates in the *cavernous* and *dorsal arteries of the penis*, after furnishing vesical, hæmorrhoidal, and urethral branches, as well as the *uterine artery* (in the female). The latter is very voluminous, and is placed in the substance of the broad ligament, above the small curvature of the uterine cornu, whence it is directed forward to the ovary, where it meets the utero-ovarian artery, after emitting numerous collateral branches, remarkable for the richness of the vascular network they form in the walls of the uterus.

The second branch of the internal iliac artery resembles the *lateral sacral artery* and its *ischiatic* branch in Solipeds; it escapes from the pelvic cavity with the great sciatic nerve, which it accompanies to behind the thigh, where it is expended, after giving off on its course spinal and gluteal twigs. It is not this branch which supplies the *coccygeal arteries;* these come, as in the Pig and Ruminants, from the *middle sacral artery.*

Fig. 369.



ABDOMINAL AORTA, WITH ITS BRANCHES, IN MAN.

1, Phrenic arteries; 2, cœliac axis; 3, gastric artery; 4, hepatic artery, dividing into right and left hepatic branches; 5, splenic artery, passing outwards to the spleen; 6, supra-renal artery of right side; 7, right renal artery longer than the left, passing outward to right kidney; 8, lumbar arteries; 9, superior mesenteric artery; 10, the two spermatic arteries; 11, inferior mesenteric artery; 12, sacra media; 13, common iliacs; 14, right internal iliac; 15, external iliac; 16, epigastric artery; 17, circumflexa ilii; 18, common femoral artery, dividing into superficial and deep femoral.

Comparison of the Internal Iliac Arteries in Man with those of Animals.

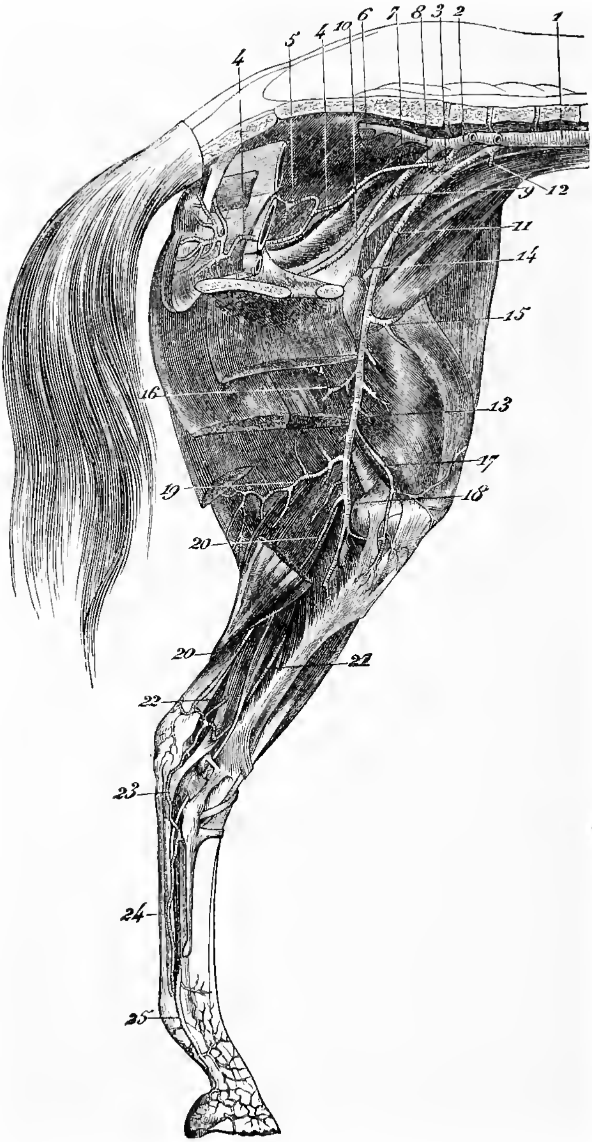
The aorta in *Man* bifurcates at the fourth lumbar vertebra to form the *common iliac arteries*, which descend to each side of the margin of the pelvis, where they divide into two branches—the *internal* and *external iliacs.*

The *internal iliac*, or *hypogastric artery*, passes beneath the sacro-iliac articulation, and breaks up into nine or eleven branches that go to the walls of the pelvic cavity, or to the organs contained in it. Their disposition somewhat resembles that of Carnivora; in their distribution they represent the various branches of the internal iliac of Solipeds. Thus we find: 1. An *umbilical artery.* 2. The *vesico-prostatic artery*, resembling the branch of the same name given off in the Horse by the internal pudic. 3. The *middle hæmorrhoidal artery*, that passes to the rectum like the branch of the internal pudic. 4. The *ileo-lumbar artery*, the iliaco-muscular of Solipeds. 5. The *lateral sacral artery*, which, behind, joins the middle sacral instead of dividing, as in the Horse, into ischiatic and lateral coccygeal. 6. The *obturator artery.* 7. *Gluteal artery.* 8. *Ischiatic.* 9. *Internal pudic*, that terminates, as in animals, by the cavernous, dorsalis penis, and the transversa perinei arteries. The arterial branches of the rectum, or *inferior hæmorrhoidal*, are furnished by the internal pudic artery.

Article IV.—External Iliac Arteries, or Crural Trunks (Fig. 370, 11).

These external branches of the terminal quadrifurcations of the posterior aorta descend on the sides of the entrance to the pelvic cavity, in describing a curve downwards and forwards, and an oblique direction downwards, backwards, and outwards. Maintained within the psoas parvus and iliacus muscles by the peritoneum covering them, they are bordered posteriorly and inwardly by the iliac vein, which isolates them from the pelvic trunk. When they arrive at the anterior border of the pubis, in the interstice separating the pectineus from

Fig. 370.



DISTRIBUTION OF THE EXTERNAL AND INTERNAL ILIAC ARTERIES IN THE MARE.

1, Posterior aorta; 2, internal iliac artery; 3, common origin of the internal pudic and the umbilical arteries (the latter is cut); 4, internal pudic artery; 5, vaginal artery; 6, lateral sacral artery; 7, origin of the gluteal artery, which arises in this instance from the lateral sacral—a circumstance most frequently observed in the Ass; 8, origin of the ilio-lumbar artery; 9, origin of the iliaco-femoral artery; 10, obturator artery; 11, external iliac artery; 12, circumflex iliac artery (cut); 13, femoral artery; 14, common origin of the deep femoral and prepubic arteries; 15, origin of the anterior great muscular artery; 16, origin of the saphena artery (cut); 17, innominate branch; 18, popliteal artery; 19, femoro-popliteal; 20, satellite artery of the great femoro-popliteal nerve; 21, posterior tibial artery; 22, its communicating branch with the saphena; 23, external plantar artery; 24, satellite artery of the internal plantar nerve; 25, digital artery.

the sartorius muscles, each is prolonged to the thigh, and takes the name of *femoral artery*; and thence into the angle of the femoro-tibial articulation, where it receives the designation of *popliteal artery*.

Before passing to the description of these two vessels—continuations of the external iliac artery—we will indicate the collateral branches which emanate from this artery itself. These are two principal—the *small testicular*, or *artery of the cord*, or *uterine*, and the *circumflex iliac*. The first having been already described (p. 620), we have only to notice the second.

Circumflex Iliac Artery (Fig. 366, 11).—This artery commences at an acute angle near the origin, and in front of, the external iliac; it sometimes emerges directly from the posterior aorta. It is directed outwards, passes between the peritoneum and the lumbo-iliac aponeurosis, and arriving at the external border of the psoas magnus muscle, or even beyond that, it bifurcates. The *anterior branch* sends its ramifications into the transverse and small oblique muscles of the abdomen, where they anastomose with the abdominal ramuscules of the lumbar and intercostal branches; the *posterior bifurcation*, after giving some vessels to the same muscles, traverses the abdominal wall a little below the external angle of the ilium, in passing between the small oblique and iliacus muscles, to descend within the anterior border of the tensor fascia lata muscle, and expend itself in front of the thigh by subcutaneous divisions.

Femoral Artery (Fig. 370, 13).

The femoral artery, a prolongation of the external iliac, which changes its name on leaving the anterior border of the pubis, at first lies beneath the crural arch, beside a cluster of lymphatic glands, in the space comprised between the pectineus, sartorius, and iliacus muscles. From this interstice it descends, accompanied by its satellite vein, which lies behind it, and the internal saphena nerve, along the pectineus and vastus internus, at the posterior border of the sartorius. It soon leaves that muscle, however, to traverse the ring formed by the two branches of the adductor magnus and the oblique concavity on the posterior face of the femur, and reaches the superior extremity of the gastrocnemius, between which it is continued, and where it assumes the name of *popliteal artery*.

On its course the femoral artery distributes a certain number of collateral branches to the adjacent parts. These are: the *prepubic*, *deep muscular*, *superficial muscular*, the *small muscular*, and *saphena arteries*.

Preparation.—The animal being placed in the first position, and the limb raised, the skin is carefully removed from the inner face of the thigh, the external generative organs in the inguinal region, and the inferior abdominal wall. The saphena vein is first to be exposed, and the branches of the artery of that name dissected; next, the prepubic artery, which is to be sought for in the inguinal canal, and its branches prepared by dissecting from their origin to their termination. The excision of a portion of the adductors of the leg and the great adductor of the thigh will sufficiently expose the femoral artery and its other collateral branches.

1. Prepubic Artery (Fig. 368, 4).

This artery originates at the artificial line of demarcation separating the external iliac from the femoral artery, at the superior extremity of the latter. It therefore emerges from that vessel at the anterior border of the pubis, and never alone, but always with the deep muscular branch, by means of a common and generally very short trunk, which springs at an acute angle from the inner side of the femoral artery.

The prepubic artery traverses the crural ring, opposite which it arises; it lies on the anterior face of Poupart's ligament, behind the neck of the inguinal canal, and after a very short course separates into two branches—the *posterior abdominal* and the *external pudic arteries.*

Posterior Abdominal Artery (*Epigastric* of Man) (Fig. 368, 5).—This leaves the external pudic artery at an acute angle, enters the femoral ring by crossing the direction of the spermatic cord, places itself between the small oblique and transverse muscles of the abdomen, passes forward along the external border of the rectus abdominis, and finally enters the substance of that muscle, where its terminal divisions anastomose with those of the anterior abdominal artery. The numerous collateral branches this artery throws off on its track principally go to the rectus muscle, or the other parts composing the inferior abdominal wall, the skin included; the superior branches communicate with the circumflex iliac.

The position this artery occupies at its origin, with reference to the abdominal ring, is worthy of remark; indicating, as it does, that in strangulated inguinal hernia, division of the ring should be made outwards, to avoid wounding the vessel.

External Pudic Artery (Fig. 368, 6).—This artery descends at first on the posterior wall of the inguinal canal, behind, and a little to the inside of, the spermatic cord; then, having passed the external ring of the canal, it bifurcates into the *subcutaneous abdominal artery*, and the *anterior dorsal artery of the penis.*

The *subcutaneous abdominal artery* is directed forward on the superficial face of the abdominal fascia, bordering in its course the insertion of the suspensory ligament of the sheath. Arriving at the anterior extremity of that ligament, it terminates in several subcutaneous divisions, one of which is inflected beyond the umbilicus to anastomose in a circle with a similar branch from the opposite artery. It gives off twigs to the scrotum, sheath, superficial inguinal glands, skin, etc. (Fig. 368, 7).

The anterior dorsal artery of the penis gains the superior border of that organ, after supplying one or two scrotal branches, and separates into two portions; one, *posterior*, meets the dorsal cavernous artery of the penis and anastomoses with it; the other, anterior, longer, more voluminous, and very flexuous during retraction of the penis, follows the dorsal border of the organ to its anterior extremity, where it enters the erectile tissue of this part. From the two branches of this anterior dorsal artery, there are given off, as in the posterior one, ramuscules which penetrate the corpus cavernosum and the walls of the urethra; they give, besides, some præputial twigs (Fig. 368, 8).

In the **female**, the external pudic artery offers a disposition which, if not similar, is yet analogous to that just indicated. As in the male, this vessel traverses the inguinal canal, and after leaving it divides into two branches: one, the *anterior*, or *subcutaneous abdominal artery*; the other, the *posterior*, or *mammary artery*. The last—the most voluminous—represents the dorsal artery of the penis. It distributes several branches to the mammary tissue, and is prolonged between the thighs by a perineal branch, which terminates in the inferior commissure of the vulva, after giving off glandular and cutaneous branches.

2. Profunda Femoris, Great Posterior Muscular Artery of the Thigh, or Deep Muscular Artery (Fig. 370, 14)

Arising in common with the prepubic artery, the profunda femoris passes backward, penetrates between the iliacus and the pectineus muscles, afterwards between the latter and the external obturator muscle. In this way it arrives beneath the deep face of the adductors of the thigh, when it becomes inflected behind the femur, and disappears in the substance of the internal and posterior crural muscles by ascending branches, which anastomose with the ischiatic artery, and descending and internal branches, the terminal ramifications of which open into those of the obturator artery.

The principal twigs of the coxo-femoral articulation are derived from this vessel.

3. Superficialis Femoris, Superficial Muscular or Great Anterior Muscular Artery (Fig. 370, 15).

Smaller than the preceding, and commencing opposite to it, but a little lower, this artery passes downwards, outwards, and forwards, runs between the sartorius and the musculo-tendinous cone which terminates in common the psoas magnus and iliacus, furnishes some ramuscules to these muscles, dips into the interstice separating the vastus internus from the rectus femoris, and is lost in the mass of the triceps cruris.

This vessel, therefore, resembles the iliaco-femoral artery, which enters this triceps by penetrating between the rectus femoris and the vastus externus.

4. Innominate or Small Muscular Arteries.

The femoral artery gives off on its course numerous small branches to the neighbouring muscles, though too diminutive to merit particular description. One of these furnishes the *nutrient artery of the femur*—the largest, perhaps, of all the arteries supplying bones. Another (Fig. 368, 17) sends to the stifle a long articular branch, analogous to the *great anastomoticus* of Man, which descends along the vastus internus, beneath the adductors of the leg, at the interstice separating these two muscles.

5. Saphena Artery (Fig. 370, 16).

This artery, remarkable for its small volume, the length of its course, and its connections with the vein of the same name, supplies the skin on the inner side of the thigh and leg.

It takes its origin, at an acute angle, from nearly the middle of the femoral artery, either alone or in common with one of the principal innominate muscular branches, and becomes superficial in passing into the interstice of the two adductors of the leg, or in traversing one of these, usually the gracilis. It lies on the surface of this muscle, beside the saphena vein, and bifurcates at the angle of union of the two roots which constitute that vessel. One of the branches accompanies the anterior vein to nearly the lower third of the leg; the other follows the posterior vein, and usually anastomoses in the hollow of the hock, above the calcis, with a branch from the posterior tibial artery, and which also communicates with one of the branches of the femoro-popliteal artery.

Popliteal Artery (Fig. 370, 18).

Preparation.—The preparation which has served for the study of the femoral artery being nearly arranged as in Fig. 370, remove from it the internal head of the gastrocnemius and the popliteus muscles.

The above name is given to the continuation of the femoral artery. This vessel follows a descending direction behind the femoro-tibial articulation, between the heads of the gastrocnemius muscle, insinuates itself beneath the popliteus, and bifurcates at the tibio-fibular arch after a course of from 6 to 8 inches, to form the *posterior* and *anterior tibial arteries.*

The popliteal artery emits on its track: 1. The *femoro-popliteal artery.* 2. Articular branches. 3. Muscular branches chiefly destined to the gastrocnemius muscle, of which it is necessary to particularize one long division that descends within the perforatus, in company with the great femoro-popliteal nerve, to terminate superficially near the tendo-Achillis, where it anastomoses with a recurrent branch of the posterior tibial artery (Fig. 370, 20).

The **femoro-popliteal artery** is the only one of these collateral branches deserving particular mention. Its origin indicates the limit of the femoral and popliteal arteries, as it is detached at a right angle below the ring of the adductor magnus, at the intermediate point of these two vessels. Placed between the semimembranosus and semitendinosus muscles on the one part, and the biceps femoris on the other, this vessel is directed from before to behind, and arrives at nearly the posterior border of the buttock, where it terminates in subcutaneous branches, after emitting descending and ascending branches. Among the first of these, which are principally destined to the gastrocnemius muscle, sometimes exists the satellite branch of the sciatic nerve, and a thin twig which descends with the external saphena nerve into the hollow of the hock, where it meets, like the preceding, a branch of the posterior tibial artery. Several of the ascending branches pass along the great femoro-popliteal nerve, and all anastomose either with the deep femoral, or with the ischiatic arteries in the substance or interstices of the ischio-tibial muscles (Fig. 370, 19).

Terminal Branches of the Popliteal Artery.

1. Posterior Tibial Artery (Fig. 370, 21).

Preparation.—Follow the indications furnished by Fig. 370.

At first situated deeply behind the tibia, beneath the popliteus, and the oblique and deep flexors of the phalanges, this artery descends towards the hollow of the hock, becoming gradually more and more superficial, and lying below the tibial fascia, behind the tendon of the oblique flexor muscle, along with its satellite vein. Arriving at the apex of the os calcis, it crosses the tibial fascia, describes an S curve, and—along with the sciatic nerve—passes beneath the tarsal arch; at the astragalus it separates into two terminal branches—the *plantar arteries.*

Collateral branches.—We cite: 1. Numerous branches destined to the posterior deep tibial muscles. 2. The nutrient artery of the tibia. 3. The tarsal articular arteries, a principal of which, along with a large venous arch, passes under the perforans, near the inferior extremity of the tibia, to be distributed outside the tarsus in descending ramuscules and ascending twigs, which extend as far as the gastrocnemius and perforatus tendons. 4. A superficial ascending branch, arising ordinarily from the second inflection of the S curvature formed by the artery at its lower extremity, situated in the hollow of the hock, anastomosing with the saphena artery, as well as with the satellite popliteal branch of the sciatic nerve, the ramifications of which, nearly all subcutaneous, are scattered within and without on the sides of the hock, and the inferior extremity of the thigh.

Terminal branches.—The two terminal branches of the posterior tibial artery are slender vessels—vestiges of the *plantar arteries* in Man. Lying on the outer side of the synovial tendinous sheath lining the tarsal groove, they are placed—one within, the other without, the perforans tendon, and descend along with the plantar nerves to the upper extremity of the metatarsus, where they leave the nerves, each to anastomose with the perforating pedal artery, forming a kind of deep arch across the upper extremity of the suspensory ligament of the fetlock —that is, from the post-metatarsal fibrous band that represents the interosseous plantar muscles of tetradactylous or pentadactylous animals.

In their course, these *plantar arteries* only distribute some insignificant ramuscules to the tarsal articulations.

From the convexity of the arch they form in uniting with the perforating pedal artery, arise four long descending branches: 1. Two superficial, innominate, and very fine arterioles accompanying the plantar nerves, and passing by the side of the flexor tendons to the sesamoid groove, where they inosculate with the collaterals of the digit (Figs. 370, 23; 371, 8). 2. Two deep branches constituting the *plantar interosseous arteries*, distinguished into *external* and *internal*. The first is only an extremely fine vascular twig, very uncertain in its disposition, and possesses no other importance in Solipeds than representing, in a rudimentary state, an artery which is of considerable size in other animals. Placed within the external metatarsal bone, it anastomoses, by its inferior extremity, with a branch of the metatarso-pedal artery. The *internal interosseous plantar artery* may be considered, if we disregard the study of analogies, as the continuation of the perforating pedal artery, which it rivals in volume. It descends to the external side of the internal metatarsal bone, beneath the margin of the suspensory ligament of the fetlock, and terminates a little above the tubercle of the external metatarsal bone, in uniting at a very acute angle with the metatarso-pedal artery. It gives off on its track: the nutrient of the large metatarsal bone; a small branch to the external interosseous artery; several ramuscules which cross the posterior border of the internal metatarsal bone to supply the connective tissue, the skin, and the tendons on the large metatarsal bone.

2. Anterior Tibial Artery (Fig. 371, 1).

Preparation.—Expose the artery by removing the anterior muscles of the leg.

The anterior tibial artery is the largest of the two branches terminating the popliteal trunk. It traverses the tibio-fibular arch, and, with its satellite veins, places itself on the anterior aspect of the tibia, down which it passes by following the deep face of the flexor metatarsi. On reaching the front of the tibio-tarsal articulation, it loses its name and takes that of the *pedal* (or *great metatarsal*) *artery*.

The anterior tibial artery gives off a great number of collateral branches, which are principally distributed to the tibial muscles. One of them, descending along the fibula, beneath the lateral extensor muscle of the phalanges, clearly represents a trace of the *peroneal artery* of Man.

3. Pedal (or Great Metatarsal) Artery (Fig. 371, 2).

A continuation of the anterior tibial artery, the name of which changes on reaching the region of the foot, the pedal artery courses downward over the anterior face of the tibio-tarsal articulation, by bending slightly outwards, and passing beneath the cuboid branch of the flexor metatarsi. At the second row of tarsal bones it divides into two branches, which we will designate *the perforating pedal* (or *perforating metatarsal*), and the *metatarso-pedal arteries*,[1] the latter continued inferiorly by the *digital arteries*, or *collaterals of the digit.*

The collateral branches emanating from this vessel are all articular or cutaneous, and of no importance.[2]

Perforating Pedal (Arteria Pedis Perforans, Perforating Metatarsal) Artery.—It crosses the tarsus from before to behind, by passing—with a venous branch—into the canal between the cuboid, scaphoid, and great cuneiform bones; it then joins the arch formed by the anastomoses of the two plantar arteries—terminal divisions of the posterior tibial (Fig. 371, 14).

Metatarso-pedal or Collateral Artery of the Cannon.[3]—Much larger than the preceding, this vessel (Fig. 371, 3) may be considered as a continuation of the pedal (or great metatarsal) artery. It is lodged at first in the fissure situated outside the large metatarsal bone, in front of the external metatarsal bone, and afterwards passes between these two bones, above the tubercle terminating the latter, reaching the posterior face of the first, between the two inferior branches of the suspensory ligament, above the sesamoid groove, where the vessel bifurcates to form the *collateral arteries of the digit.*

The collateral artery of the cannon receives, a short distance above this terminal bifurcation, the internal plantar interosseous artery.

On its course it gives off: 1. Numerous anterior ramuscules for the connective tissue, tendons, ligaments, and the skin on the anterior face of the metatarsus and fetlock. 2. Some slender posterior divisions, one of which ascends within the external plantar interosseous artery, after furnishing several ligamentous, tendinous, and cutaneous ramuscules in the posterior metatarsal region.

Digital Arteries, or Collateral Arteries of the Digit (Figs. 370, 25; 371, 5, 5; 377, 11).—Remarkable for their volume, these arteries carry blood to the keratogenous apparatus enveloping the ungual phalanx, and from this distribution derive such importance that they deserve a detailed study.

[1] The vessel we have here named the *perforating pedal artery*, is only the like termination of the same artery in Man. The *metatarso-pedal artery* ought to be regarded as the representative of one of the dorsal interossei arteries, because of its position in the interstice of the middle and external lateral metatarsal bones. The dorsal interstice of the inner side also lodges an interosseous branch, usually supplied by the external plantar artery; but its diameter is so diminished that, in order to avoid complexity by introducing an almost useless element into the didactic description of the posterior tibial artery, we have thought it our duty to neglect its indication.

[2] One of these may be regarded as the analogue of the *dorsalis pedis* of Man.

[3] Rigot has designated this artery—we do not know why—the *superficial plantar artery.* It would have been better to have allowed it to retain the name given to it by Girard—the *lateral artery of the cannon.* This is not the only instance in which the attempts of Rigot to conform the nomenclature of the arteries to that of anthropotomists has proved unfortunate, as he has not always succeeded in finding in the Horse the real representatives of the arteries in Man. The aim of this work does not allow us to discuss the vicious determinations and denominations of Rigot every time we meet them. We are content to change them, purely and simply, leaving to the judgment of the reader, should this matter interest him, the task of deciding if we are right.

Origin.—The digital arteries succeed the terminal extremity of the collateral of the cannon, and separate from one another in forming an acute angle below the sesamoidean venous arch, above the fetlock-joint, between the two branches of the suspensory ligament, behind the inferior extremity of the large metatarsal bone, and in front of the flexor tendons of the phalanges.

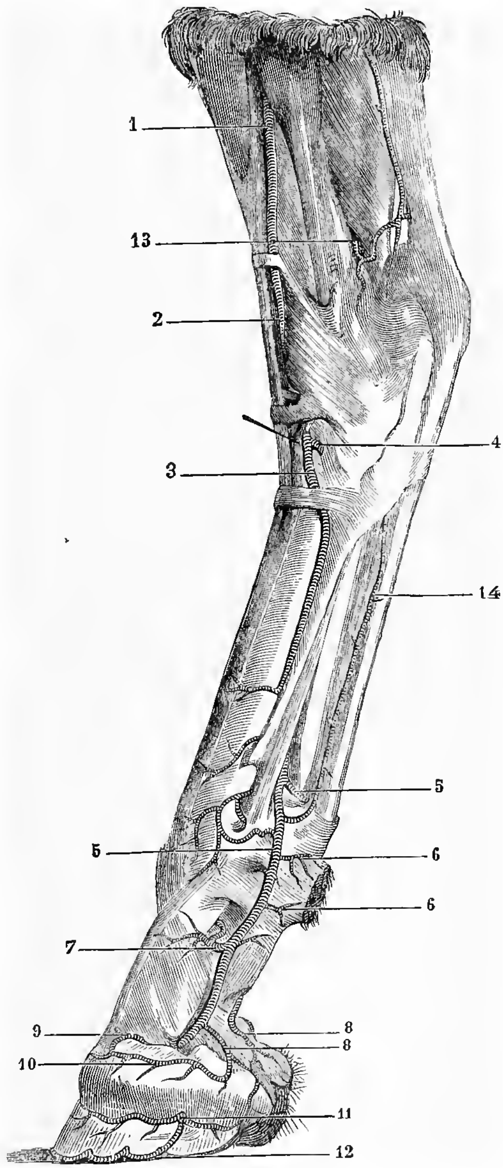
Course and Relations.—These vessels descend—one to the right, the other to the left, from the lateral parts of the metacarpo-phalangeal (and *metatarso-phalangeal*) articulation to the internal face of the basilar process, where they bifurcate to form the *plantar* and *preplantar ungual arteries.*

"In the whole of this course, it (the *digital artery*) follows the track of the flexor tendons, resting on their margins, and maintained there by loose connective tissue. Behind, it is flanked by the plantar nerve, which covers a portion of its surface, enlaces it with numerous filaments, and is so closely associated with it in all its flexuosities, as to form but a single cord with it.

"In front, it is margined, though for a short distance, by its satellite vein, which for the whole of its track rests on the lateral faces of the two first phalanges.

"At its upper part, near its origin, and on the lateral

Fig. 371.



PRINCIPAL ARTERIES IN THE POSTERIOR FOOT OF THE HORSE.

1, Anterior tibial artery; 2, pedal or great metatarsal artery; 3, metatarso-pedal or perforating metatarsal; 4, arteria pedis perforans; 5, 5, digital arteries; 6, 6, arterioles of the ergot; 7, perpendicular artery; 8, artery of the plantar cushion; 9, anterior branch of the coronary circle; 10, circumflex artery of the coronary cushion; 11, preplanter ungual artery; 12, inferior circumflex artery of the foot; 13, collateral branch of the posterior tibial artery distributed to the external surface of the hock; 14, arteriole furnished by the arch formed by the union of the two plantar arteries with the arteria pedis perforans, across the superior extremity of the supensory ligament of the fetlock.

portions of the metacarpo-phalangeal articulation, the digital artery is crossed from behind to before by the anterior branch of the plantar nerve, and it is covered for the whole of its extent by the fascia that continues the proper tunic of the plantar cushion, the lateral ligamentous band of which cuts its direction obliquely downwards and forwards, at the middle portion of the first phalanx." [1]

Collateral divisions.—These are: 1. At the fetlock, numerous fine branches distributed to the metacarpo-phalangeal articulation, but particularly to the sesamoid sheath and the tendons lodged in it.

2. To the environs of the upper extremity of the first phalanx, slightly ascending and sometimes voluminous twigs, for the tissue of the ergot (the horny tubercle behind the fetlock).

3. Towards the middle of the same bone, the vessel named by Percivall the *perpendicular artery*, and correctly so, for it arises at a right angle from the digital artery to divide almost immediately afterwards into two series of ramifications—anterior and posterior. The anterior branches are in nearly every instance two principal: one ascending, passing beneath the check-band of the extensor tendon, and climbing to the capsular ligament of the fetlock-joint to meet the arterial divisions furnished directly to that ligament by the collateral artery of the cannon; the other descending, which reaches the side of the second phalanx, where its ramuscules anastomose with the coronary circle and the circumflex artery of the coronary cushion. The posterior ramifications consist most frequently of two principal branches—one ascending, the other descending; these insinuate themselves between the flexor tendons and the sesamoid ligaments, to be distributed to these organs, but especially to the synovial membrane of the large sesamoidean bursa. Sometimes it is seen to arise alone from the digital artery. It must here be noted, that the divisions furnished by the anterior branches of this perpendicular artery communicate with those of the opposite side in front of the first phalanx, either above or below the principal extensor of the digit; and that the posterior branches exhibit a series of analogous anastomoses. The body of the first phalanx is therefore enveloped on every side by an arterial plexus.

4. At different elevations on the first and second phalanges, several tendinous and cutaneous twigs, which are of no importance.

5. The *artery of the plantar cushion*, which arises at the superior border of the lateral cartilage, is directed obliquely backward and downward, and placed within the posterior border of that cartilage, to be distributed to the middle portion of the complementary apparatus of the third phalanx, as well as to the villous tissue and the coronet. The branch expended in the latter sometimes proceeds directly from the digital artery; it is a very remarkable vessel, is inflected from before to behind, crossing the posterior border of the pedal cartilage, creeping on the internal face or in the texture of the skin, a little above the coronet, parallel with that portion of the keratogenous apparatus, and terminates by anastomosiug with a branch of the artery now to be noticed.

6. The *coronary circle*,[2] formed by two transverse branches—one anterior, the other posterior, springing at a right angle from the digital artery, under the cartilaginous plate of the os pedis—passes around the coronary bone to meet the analogous branches of the opposite artery, to anastomose with them directly and by inosculation. The coronary circle therefore presents two distinct por-

[1] H. Bouley, *Traité de l'Organisation du Pied du Cheval.* Paris, 1851.

[2] So named because it encircles the coronet.

tions: one posterior, placed above the superior border of the small sesamoid, beneath the perforans tendon; the other anterior, more extensive and voluminous, covered on the sides by the lateral cartilages of the foot, and in its front or middle part by the expansion of the anterior extensor tendon of the phalanges.

The collateral ramuscules furnished by the posterior part of the circle are small, few, and of no interest.

Among the branches arising from the anterior portion, there is only a single pair of arteries to be noted, which are remarkable for their mode of distribution and their volume. They originate near the border of the extensor tendon, and immediately divide into two divergent branches: one the internal, which passes across that tendon to anastomose with the homologous branch of the opposite side; the other, external, passes backward to meet the cutigeral branch furnished by the artery of the plantar cushion, and joins that vessel. From this disposition results a very fine superficial vascular arch around the coronet, which is well named the *circumflex artery of the coronary cushion;* it is situated a little above the cutidural artery, beneath the skin of the coronet, and looks as if encrusted in that membrane; by its two extremities it rests on the arteries of the plantal cushion, and is fed by the two principal vessels of the coronary circle; while it furnishes ascending anastomosing ramuscules to the inferior divisions of the perpendicular artery, as well as numerous descending branches passing into the coronary cushion and the laminal tissue of the foot.

Such is the ordinary disposition of the coronary circle and its superficial arch—the circumflex artery of the coronary substance; though it varies much in different animals, and even in the feet of the same animal. To attempt to describe here the variations we have seen would be supererogatory, and we may limit ourselves to saying that these varieties were almost exclusively confined to the origin of the branches composing these two circular vessels and their manner of arrangement, without modifying in any way the general disposition of the circles.[1]

Terminal divisions.—These are, as has been already mentioned, the *plantar* and *preplantar ungual arteries.*[2]

a. The *preplantar ungual artery* is the smallest of these two terminal branches. Situated at first inside the basilar process of the third phalanx, it turns round this to traverse the notch which separates this process from the retrossal eminence, is lodged with a satellite nerve in the preplantar fissure, which it crosses from before to behind, and terminates near its anterior extremity by several divisions that bury themselves in the os pedis. In its course, it distributes: 1. Before passing into the sub-basilar notch, a deep retrograde branch destined to the bulb of the heel and the villous tissue. 2. Immediately after leaving that notch, a second retrograde branch, whose divisions pass backward, behind the great circumflex artery of the pedal bone. 3. During its passage in the preplantar fissure, several ascending and descending branches which ramify in the laminal tissue; the first anastomose with the descending divisions of the coronary circle and the circumflex artery of the coronary cushion.

[1] We may notice here one of these variations, which is somewhat frequently met with in the anterior limb. This consists in the anterior descending branch of the perpendicular artery uniting at its terminal extremity with the circumflex artery of the coronary substance, which it concurs to form.

[2] In all treatises on anatomy, these vessels are simply designated the *plantar* and *preplantar arteries.* We have added the epithet *ungual* to distinguish these arteries from the properly so-called *plantar* branches—the terminal divisions of the posterior tibial artery.

b. The *plantar ungual artery* ought to be regarded as a continuation of the digital artery, because of its volume and direction. Lodged at first, with a fine nervous branch, in the plantar fissure, it afterwards enters the canal of the same name, and thus penetrates into the semilunar sinus of the os pedis, where it anastomoses by inosculation with the opposite artery, forming a deep vascular arcade which we designate the *plantar arcade* or *circle*, or, after M. H. Bouley, the *semilunar anastomosis* (Fig. 377, 12).

Two orders of branches emanate from the convexity formed by this anastomotic loop. The *ascending* order "irradiate in the spongy framework of the third phalanx, and like so many hair-roots, escape by numerous openings from its anterior face, where they form a very intricate plexus by anastomosing, in the texture of the laminal tissue, with the extreme divisions of the anterior branch of the digital artery and those of the coronary circle. . . . It is to these divisions that Spooner has given the name of *anterior laminal arteries*" (H. Bouley).

The *descending* order, much more considerable, named by Spooner (W. C., of Southampton) the *inferior communicating arteries*, arise at a right angle from the anterior circumference of the semilunar anastomosis, traverse in a divergent manner the tissue of the phalanx, and make their exit by the large foramina situated a little above the inferior border of the bone, where they furnish a multitude of ascending ramuscules which concur to form the arterial network of the laminal tissue. "Then they anastomose transversely by a succession of little arcades which are thrown from one to the other, and in this way give rise to a great circumflex canal which follows the contour of the parabolic curve exhibited by the thin border of the os pedis, on its inferior face" (H. Bouley). This vascular arch, which we purpose naming the *inferior circumflex artery of the foot* (Fig. 377, 12), to distinguish it from the circumflex of the coronary cushion, is joined by its extremities to the preplantar artery, in the same manner that the latter circumflex is united to the artery of the plantar cushion. From its concavity it throws off some fourteen or fifteen convergent branches, which are destined to the villous tissue of the sole.

Differential Characters of the External Iliacs in the other Animals.

1. External Iliac Arteries of Ruminants.

In the **Ox**, apart from the considerable volume of the great muscular arteries of the thigh, the external iliac, as well as the femoral and popliteal arteries continuing it, comport themselves almost the same as in the Horse. It is only when we reach the *posterior* and *anterior tibial arteries* that we find some peculiarities worthy of notice.

Posterior tibial artery.—Much more voluminous than that of Solipeds, this artery follows the same course, and terminates in an analogous manner: forming at its lower extremity two plantar branches, which anastomose with the perforating pedal artery behind the superior extremity of the principal metatarsal bone, and beneath the suspensory ligament. But these two branches are far from possessing the same volume; the internal is incomparably the largest, and appears to be the direct continuation of the posterior tibial artery.

From this anastomosis results, as in the Horse, two series of *metatarsal branches*—a *deep* and a *superficial*.

The *deep branches*, two or three in number, form on the posterior face of the metatarsal bone, below the suspensory ligament, the posterior interosseæ, mixed with two or three reticulated venous branches; they anastomose by their inferior extremity with a perforating branch of the collateral of the cannon.

The *superficial branches*, similar to those which accompany the plantar nerves in the Horse, are of very unequal calibre; the external is so rudimentary that it often escapes dissection; the internal in reality continues the plantar artery of the same side. Both are united to the perforating branch already noticed.

Anterior tibial artery.—After passing down along the leg on its antero-external face, as in Solipeds, this vessel arrives on the hock, where it takes the name of *pedal artery*, and furnishes the *perforating-pedal artery*; it is continued by the *metatarso-pedal* or *collateral artery of the cannon.*

a. The *perforating pedal artery* does not differ from that of the Horse.

b. The *metatarso-pedal*, or *collateral of the cannon*, descends, flanked by two satellite veins, in the channel on the anterior face of the metatarsal bone, giving off towards the inferior extremity of that channel, the *perforating branch* already spoken of, and is continued into the digital region as the *common digital artery.*

The *perforating branch* of the collateral of the cannon passes into the foramen pierced from before to behind, across the inferior extremity of the metatarsal bone, arriving beneath the suspensory ligament, and then divides into several *ascending* and *descending branches.* The first join the deep and superficial posterior metatarsal arteries furnished by the plantar and pedal perforating arteries. Among the second, we notice three digital arteries, *facsimiles* in miniature of those which will be described in the anterior limb: two lateral, descending on the eccentric side of the phalanges; a median, turning within the flexor tendons to place itself behind them on the middle line of the digital region, and prolonged into the interdigital space, where it anastomoses with a branch of the principal artery of the digits.

The latter artery—the *common digital*—descends into the space between the digits, after passing beneath the capsular ligament of the metatarso-phalangeal articulations, in the notch between the two articular surfaces of the metatarsal bone, and terminates above the inferior extremity of the first phalanx by two *ungual arteries*, the description of which will be reserved until describing the arteries of the anterior limb. In the number of collateral branches emanating from this vessel, there may be particularly remarked a large offshoot which arises a little before the separation of the two ungual arteries, and is directed from before to behind, dividing at the posterior part of the interdigital space into several divisions, the principal of which are: 1. Two transverse branches passing between the flexor tendons and the phalanges, to be joined to the lateral digital arteries. 2. A single ascending branch, joining with the posterior median digital artery. 3. A descending branch, also single, dividing into two portions which reach the heels, to be distributed to the plantar cushion and the villous tissue. These branches represent the arteries of the plantar cushion in the Horse, and will be noticed more in detail in the description of the arteries of the anterior limb, where in principle they are found to be exactly like these.

2. External Iliac Arteries of the Pig.

The distribution of these vessels in the **Pig** is remarkably like that we have described as existing in Ruminants, even in the terminal portions of the limbs, notwithstanding the complete development of the two lateral digits. It may be noted, however, that the posterior tibial artery is somewhat slender, and that it is singularly increased by its anastomosis with the saphena artery, the dimensions of which are relatively considerable.[1]

3. External Iliac Arteries of Carnivora.

The external iliac is divided in the Carnivora, as in the other animals, into three sections: the *proper iliac artery*, the *femoral artery*, and the *popliteal artery*, terminated by the *tibial branches.*

Proper iliac artery.—This vessel does not give rise to any branch, as the *circumflex iliac* comes directly from the posterior aorta.

Femoral artery.—As in the Horse, this gives off: 1. Several *muscular innominate branches.* 2. Two *great muscular arteries*, the posterior of which furnishes the *prepubic artery.* 3. A *saphenal branch.*

In the **Bitch**, the *external pudic artery*, emanating from the *prepubic* division, presents some peculiarities in its distribution. It gives off a long branch which is placed in the texture of the mammæ, and passes forward to meet and unite with the mammary branch furnished by the internal thoracic artery; it then runs between the two thighs in a flexuous manner, and reaches the lips of the vulva, where it ends in numerous ramuscules that anastomose with the vulvar divisions of the internal pudic artery.

The *saphena artery* is as remarkable for its large volume as for its destination. It descends

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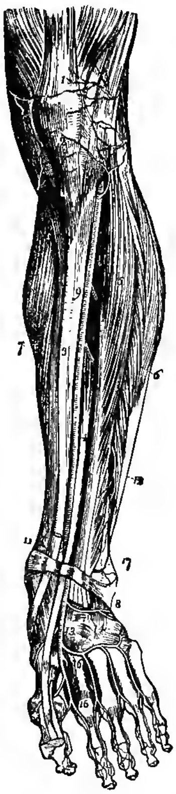
[1] In small Ruminants, the posterior tibial artery, properly speaking, is equally rudimentary; the saphena artery constitutes the principal vessel. From a note which we made a long time ago, it appears the first vessel is altogether absent sometimes, and that the plantar divisions come exclusively from the saphena, as in the Carnivora.

on the internal face of the leg, furnishing numerous subcutaueous divisions, and terminates at the hock by several slender *plantar twigs*, which accompany the flexor tendons. Among the branches given off by this vessel iu its course, it is necessary to distinguish two—one which follows the anterior branch of the saphena vein to the hock, where it communicates by its terminal divisions with the tarsal artery; the other arises a little lower, passes beneath the

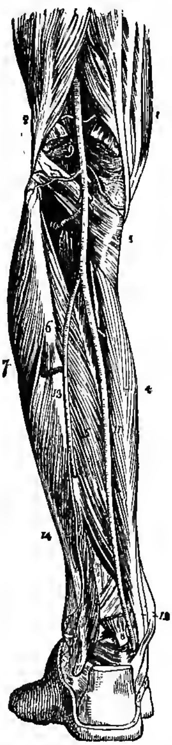
Fig. 372.



ANTERIOR ASPECT OF HUMAN LEG AND FOOT.

1, Tendon of insertion of the quadriceps extensor muscle; 2, insertion of the ligamentum patellæ; 3, tibia; 4, extensor longus digitorum; 6, peronei; 7, inner belly of gastrocnemius and soleus; 8, annular ligament; 9, anterior tibial artery; 10, its recurrent branch inosculating with (2) inferior articular and (1) superior articular arteries, branches of the popliteal; 11, internal malleolar artery; 17, external ditto, inosculating with anterior peroneal artery, 12; 13, dorsalis pedis artery; 14, tarsea and metatarsea; 15, dorsalis hallucis artery; 16, continuation of dorsalis pedis into sole of foot.

Fig. 373.



POSTERIOR ASPECT OF HUMAN LEG.

1, Tendons of inner hamstring; 2, ditto of biceps; 3, popliteus muscle; 4, flexor longus digitorum; 5, tibialis posticus; 6, fibula; 7, peronei muscles; 8, lower portion of flexor longus pollicis, with its tendon; 9, popliteal artery, giving off articular and muscular branches; 10, anterior tibial artery; 11, posterior tibial artery; 12, relative position of tendons and artery; 13, peroneal artery; 14, posterior peroneal.

phalangeal flexor muscles, and is expended on the hock in articular and malleolar branches. In the latter branch we see a trace of the *peroneal artery* of Man. The saphena itself, considered as a whole, and particularly towards its inferior moiety, supplements the posterior tibial artery.

Popliteal artery.—This artery gives an important *femoro-popliteal branch*, and enters the tibio-peroneal arch to constitute the *anterior tibial artery*, after distributing on its course muscular ramuscules—rudiments of the posterior tibial artery of other animals.

The *anterior tibial artery*, arriving in front of the hock, detaches the *tarsal artery*—a voluminous branch, divided near its origin into several superficial superior and inferior branches. It continues to descend, traverses from before to behind the superior part of the third intermetatarsal space, and terminates by an arterial arch situated beneath the flexor tendons; from this arch emanate ascending divisions, that anastomose with the plantar arteries, and three large descending or *digital branches*, which affect the same disposition as three analogous principal arteries emanating from the superficial palmar arch of the anterior limb.

Fig. 374.

ARTERIES OF SOLE OF HUMAN FOOT.

1, Under surface of os calcis; 2, musculus accessorius; 3, long flexor tendons; 4, tendon of peroneus longus; 5, termination of posterior tibial artery; 6, internal plantar; 7, external plantar; 8, plantar arch giving off four digital branches, three of which are seen dividing into collaterals for adjoining toes.

Comparison of the External Iliacs of Man with those of Animals.

In Man, the *external iliac* forms the external branch of the bifurcation of the common iliac; it extends to the crural arch, where it takes the name of *femoral artery*. It furnishes the *circumflexa ilii* and *epigastric*: the latter resembling, in its distribution, the posterior abdominal branch given off by the prepubic artery in the Horse.

The *femoral artery* has the same general disposition as in animals, and almost the same collateral branches. There is no prepubic artery; the divisions furnished by this trunk in Solipeds originate separately from the femoral artery; these are: the *abdominal tegumental artery* (*superficial epigastric*), and the *external pubic arteries*—the one resembling the subcutaneous abdominal artery, and the others the branches of the external pudic artery of animals.

The *popliteal artery* is a superficial vessel situated at the posterior face of the knee-joint, in a lozenge-shaped space limited by the muscles of the region, and named the *popliteal space*. At the tibio-peroneal arch it bifurcates, and constitutes the anterior tibial and the tibio-peroneal trunks.

The *tibio-peroneal artery* does not exist in animals in which the peroneal artery is in a rudimentary state, in consequence of the feeble development of the peroneus. This trunk is short, and furnishes the nutrient artery of the tibia, then divides into the *peroneal* and *posterior tibial arteries*. The first descends to the external malleolus, along the inner face of the tibia, and terminates in two branches, one of which, the anterior peroneal, communicates with the dorsal artery of the tarsus—a branch of the pedal. The *posterior tibial*, on reaching the concavity of the calcis, constitutes the *internal* and *external plantar arteries*. The *internal plantar* is directed forwards, beneath the sole of the foot, and is lost in the muscles of the great toe, or forms the collateral of the latter vessel. Beneath the tarsal articulations, the *external plantar* describes a curve, having its concavity backwards, and anastomoses, at the fourth intermetatarsal space, with the termination of the dorsalis pedis; from this results a plantar arch, which gives off, from without to within: 1. The external collateral of the little toe; 2, 3, 4, 5, the *interosseous plantar* (or *digital*) *arteries* of the first, second, third and fourth intermetatarsal spaces; these arteries, at the root of the toes, bifurcate to furnish collaterals to these organs.

The *anterior tibial artery*, situated on the anterior face of the interosseous ligament that unites the tibia to the peroneus, extends to the annular ligament of the tarsus, where it is continued by the *dorsalis pedis*, which descends along the dorsum of the foot to gain the summit of the fourth interosseous space.

The *dorsal artery of the metatarsus* (*metatarsea*) is almost *nil* in Solipeds. In Man it is directed transversely to the tarsus, from within to without; its terminal branches unite on the dorsum of the tarsus, and the arch it forms gives off the dorsal interosseous arteries of the three first spaces. These communicate above and below, in the intermetatarsal spaces, with the plantar interosseous arteries by the *anterior* and *posterior perforating arteries;* finally, at the base of the toes they bifurcate to form the *collateral arteries of the toes.*

The *dorsal collateral artery of the fourth space* represents the vessel described in the Horse by the name of metatarso-pedal artery, or collateral of the cannon; it forms the internal collateral dorsal of the fourth toe, and external collateral of the great toe.

The *dorsalis pedis,* after giving off the last-named vessel, dips into the fourth space and reaches the lower surface of the foot, where it anastomoses with the internal plantar artery. In this last portion of its course it resembles the vessel we have named the perforating pedal in Solipeds.

Article V.—Anterior Aorta (Fig. 375, 1).

This vessel, the smallest of the two trunks succeeding the common aorta, is no more than 2 or 2½ inches in length at the most. It leaves the pericardium to pass between the two layers of the mediastinum in an oblique direction from below upwards and behind forwards, above the right auricle, below the trachea, and to the left of the anterior vena cava. After furnishing some insignificant twigs to the pericardium and mediastinum, it divides into two branches which constitute the *brachial trunks* or *axillary arteries.*

In Pachyderms, Carnivora, and Rodents, the anterior aorta does not exist, and the axillary arteries arise directly from the common aorta, towards the point from which the anterior aorta arises in other animals.

Article VI.—Brachial Trunks, or Axillary Arteries (Fig. 375, 2, 3).

The brachial trunks—terminal branches of the anterior aorta—are distinguished into left and right. The latter is much larger than the former, because it furnishes arteries to the head. It is also named the *arteria innominata.*

Origin.—They separate from one another at an acute angle, the left being a little more elevated than the right.

Course and direction.—Both branches are directed forwards, between the layers of the anterior mediastinum and beneath the trachea; gaining the entrance to the chest, and leaving it by turning round the anterior border of the first rib, under the insertion of the scalenus, they become inflected backwards and downwards, to be placed, one to the right, the other to the left, at the internal face of the anterior limb, in the middle of the nerves of the brachial plexus, and continue within the arm, assuming the name of *humeral artery* on leaving the interstice which separates the subscapularis muscle from the adductor of the arm.

In its thoracic course, the left trunk describes a curve—the convexity being upwards—the right taking a rectilinear direction.

Relations.—In studying the relations of the brachial trunks, we recognize two principal portions—one thoracic, placed in the chest; the other axillary, situated within the limb. In their thoracic portion, the brachial trunks, at first lying beside each other, separate slightly in front to reach the internal face of each of the two first ribs. They are accompanied by the cardiac, pneumogastric, inferior laryngeal, and diaphragmatic nerves, and are included, as already noticed, between the two layers of the anterior mediastinum. The right occupies nearly the middle line beneath the inferior face of the trachea, to the left and above the anterior vena cava. The left slightly rises on the side of the trachea, and generally corresponds inwardly to the thoracic duct.

In their axillary portion, these vessels accompany the corresponding venous trunks, cross the terminal tendon of the subscapularis muscle in passing below the humeral insertion of the deep pectoral, and among the branches of the brachial plexus, but embraced more particularly by the median, anterior humeral, and ulnar nerves.

Distribution.—The axillary arteries give off, on their course, eight collateral branches. Four arise from the thoracic portion: three upper—the *dorsal, superior cervical*, and *vertebral arteries*; and an inferior—the *internal thoracic*. Two are detached at the first rib—one downwards, the other forwards; these are the *external thoracic* and *superior cervical arteries*. Two originate from the axillary portion of the trunk and pass upwards: they are the *supra-* and *subscapular arteries*. After furnishing the latter vessel, the brachial trunk is continued by the *humeral artery*.

Independently of all these branches, the right axillary artery gives off, near its origin, the common trunk of the two *carotid arteries*, which will be studied in a separate article.

Preparation.—The subject being placed on the right side, remove the skin and the left anterior limb, in order to make the dissection at two periods.

First period.—Dissect all the intra-thoracic portion of the left axillary artery and its collateral branches, as in Fig. 375, taking care to leave the inferior cervical artery (which has been cut in the figure to render the drawing more distinct) attached by its superior extremity to the middle portion of the mastoido-humeralis, which has not been disturbed.

Second period.—Prepare, on the separated limb, the extra-thoracic portion of the vessel and all the arteries it furnishes, in taking as guides Figs. 376, 377.

Collateral Branches of the Axillary Arteries.

1. Dorsal, Dorso-muscular, or Transverse Cervical Artery (Fig. 375, 4).

Chiefly directed to the muscles of the withers, this artery—the first given off by the brachial trunk—crosses outwardly the trachea, thoracic duct, œsophagus, great sympathetic nerve, and the longus colli, in proceeding beneath the mediastinal layer; it reaches and passes over the second intercostal space, bends slightly backwards, and places itself in the interstice separating the angularis scapulæ and serratus magnus from the inferior branch of the longissimus dorsi, where it separates into several divergent branches. The majority of these ascend towards the superior border of the withers, neck, and shoulders, by gliding between the latter muscles, the splenius, and the serratus anticus on the one part, and the serratus magnus and rhomboideus on the other, to be distributed to those muscles and the integuments covering them. The most anterior of these branches passes between the splenius and complexus muscles, parallel with the superior cervical artery, which is in front of it, and communicates by its ramuscules with the latter vessel, as well as with the vertebral and occipito-muscular arteries. The last-named branch is sometimes long and voluminous, and partly supplements the superior cervical, as is exemplified in the specimen which served for Fig. 375.

Before leaving the thorax, the dorsal artery gives off some unimportant ramuscules and the *subcostal artery* (*superior intercostal* of Man). This branch (Fig. 375, 5) curves backwards and, with the sympathetic chain, places itself beneath the costo-vertebral articulations, against the longus colli, furnishing the second, third, and fourth intercostal arteries and the corresponding spinal branches, and terminating at the fifth intercostal space by either forming the artery which descends into that space, in anastomosing by inosculation with a branch emanating from the first posterior intercostal artery, or by expending itself in the spinal muscles. Frequently, the second intercostal and its spinal branch come directly from the dorsal artery ; the fifth also often arises from the posterior aorta.[1]

On the right side, the dorsal artery always proceeds from a trunk common to it and the superior cervical artery—a circumstance sometimes observed in the left. This trunk has no relation with the œsophagus.

2. Superior Cervical, Cervico-muscular, or Deep Cervical Artery (Fig. 375, 6).

This vessel arises in front of the preceding artery, has the same relations in the thoracic cavity, which it leaves by passing between the two first ribs, behind the last costo-transverse articulation ;[2] it is then directed upwards and forwards, passing beneath the inferior branch of the longissimus dorsi and complexus muscles, courses in a flexuous manner through the space comprised between the latter muscle on one side, and the superior branch of the longissimus dorsi and cervical ligament on the other, and arrives at the second vertebra of the neck, where its terminal divisions anastomose with the branches of the occipito-muscular, vertebral, and even the dorsal arteries.

The superior cervical artery distributes in its course : 1. The first intercostal artery and the first spinal branch. 2. Very numerous branches which are expended in the muscles and teguments of the cervical region, as well as in the large ligament occupying the middle plane of that region ; among these branches, one longer than the others traverses the complexus muscle to place itself between it and the splenius, and is sometimes supplemented in great part by the dorsal artery.

3. Vertebral Artery (Fig. 375, 7).

Arising at an acute angle from the axillary artery at the first intercostal space, and covered at its origin by the mediastinal layer, the vertebral artery proceeds forward and upward, within the first rib, outside the œsophagus,[3] the trachea, and the inferior cervical ganglion, and is situated at the bottom of the interstice separating the two portions of the scalenus, with the fasciculus of branches arising from the brachial plexus, which is a little above the vessel. It then passes beneath the transverse process of the seventh cervical vertebra, and traverses the series of cervical foramina, hidden beneath the intertransversalis colli, to anastomose in full canal with the retrograde branch of the occipital artery, at the atlo-axoid articulation, underneath the obliquus capitis posticus muscle.

In its track, it detaches at each intervertebral space numerous branches, which may be divided into inferior, superior, external, and internal. The first chiefly pass to the scalenus, longus colli, and rectus capitis anticus major. The second, which are incomparably larger and more numerous than all the others, are destined to the complexus and trachelo-mastoideus, semispinalis, and longissimus dorsi muscles ; they anastomose with the divisions of the superior cervical and occipito-muscular arteries. The external branches are very small, and pass to the intertransversalis muscle. The internal branches enter the intervertebral foramina to join the middle spinal artery.

[1] For the description of these arteries, see p. 611.

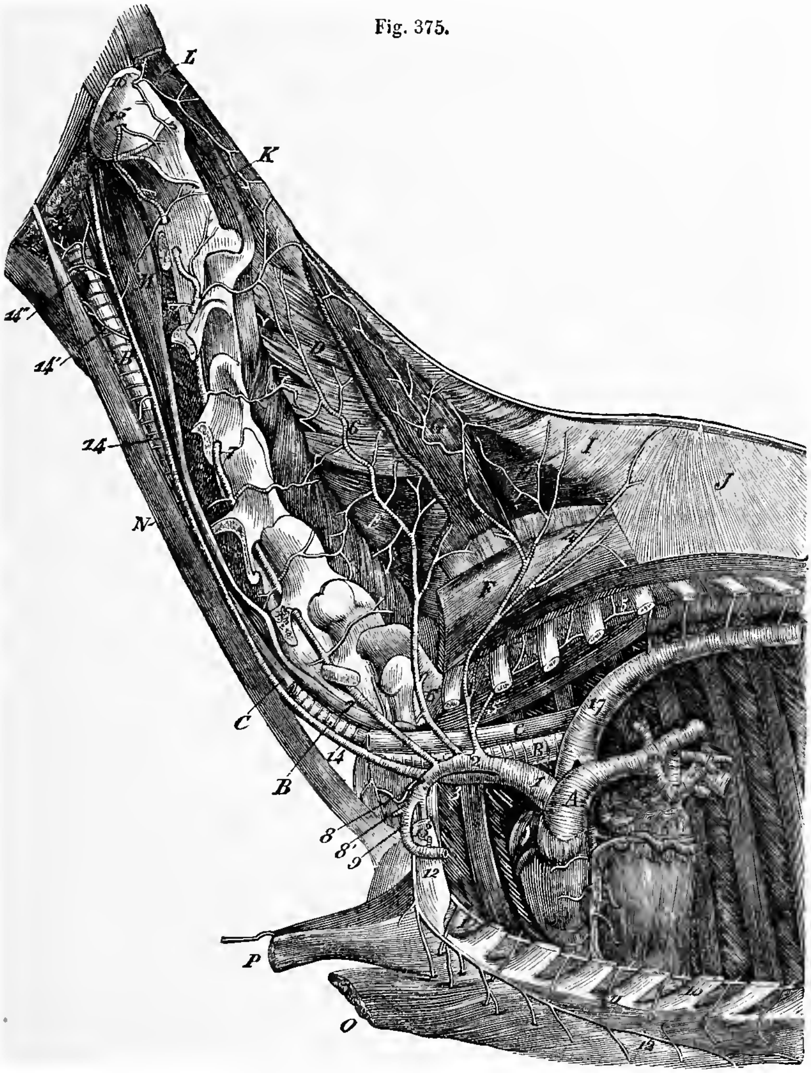
[2] We have seen it escape, along with the dorsal artery, by the second intercostal space.

[3] On the right, these relations with the œsophagus are not present.

4. Internal Thoracic (Pectoral), or Internal Mammary Artery (Fig. 375, 9).

The *internal thoracic artery* emerges from the brachial trunk at the first rib,

Fig. 375.



DISTRIBUTION OF THE ANTERIOR AORTA.

1, Anterior aorta; 2, left axillary artery; 3, right axillary artery; 4, dorsal artery; 5, subcostal artery; 6, superior cervical artery; 7, vertebral artery; 8, 8′, inferior cervical artery; 9, origin of the internal thoracic artery; 10, origin of one of the external or intercostal branches of this artery; 11, one of its inferior ramuscules; 12, external thoracic artery; 13, origin of the suprascapular artery; 14, common carotid artery; 14′, accessory thyroid artery; 14″, thyro-laryngeal artery; 15, atloido-muscular artery; 16, occipito-muscular artery; 17, posterior aorta. A, Pulmonary aorta; B, trachea; C, œsophagus; D, cervical ligament; E, superior branch of the longissimus dorsi muscle; F, inferior branch of the same; G, complexus muscle; H, splenius muscle; I, J, originating aponeurosis of the splenius and the serratus anticus muscles; K, section of the obliquus capitis major; L, rectus capitis posticus major; M, rectus capitis anticus major; N, sterno-maxillaris; O, P, deep and superficial pectoral muscles turned downwards.

and immediately descends along the inner face of that bone to the sternum, remaining covered by the pleura. It then bends backwards, passes under the triangularis sterni muscle and above the sternal cartilages, which it crosses near the chondro-sternal articulations, and reaches the base of the xiphoid cartilage, where it ends in two branches—one *abdominal*, the other *thoracic*, and which have been named the *anterior abdominal* and *asternal arteries*.

In its course, the internal thoracic artery sends off collateral branches, which may be distinguished into superior, inferior, and external. The *superior* are always very slender, and proceed to the pericardium and mediastinum. The *inferior* (Fig. 375, 11) are very large, and traverse the intercostal spaces to enter the pectoral muscles, where they meet the ramifications of the external thoracic artery. The *external branches* (Fig. 375, 10) follow the intercostal spaces; each generally divides into two branches, which finally anastomose by inosculation with the terminal divisions of the first seven intercostal arteries.

Terminal branches of the internal thoracic artery. 1. *Anterior abdominal artery.*—This vessel separates from the asternal artery at an acute angle, and passes directly backward to escape from the chest by coursing beneath the xiphoid cartilage; it then places itself on the superior face of the rectus abdominis, which it enters, after detaching lateral branches to the abdominal walls, and anastomoses by its terminal ramifications with the posterior abdominal artery.

2. *Asternal artery.*—This vessel glides within the cartilaginous circle formed by the false ribs, in crossing the digitations of the transversalis abdominis, and terminates at the thirteenth intercostal space, in which it ascends to anastomose with the corresponding intercostal artery. It supplies in its track intercostal branches, which comport themselves like the analogous branches of the internal thoracic artery; fine diaphragmatic arterioles; and abdominal divisions, which particularly ramify in the transversalis abdominis.

5. External, Inferior Thoracic, or External Mammary Artery (Fig. 375, 12).

Principally distributed to the deep pectoral muscles, this artery commences at an acute angle in front of, but close to, the preceding, turns the anterior border of the first rib, and then passes back against the internal face of the deep and superficial pectoral muscles, in which are extended its collateral and terminal divisions. It gives off a fine branch which accompanies the spur vein, and ramifies in the panniculus carnosus.

This artery sometimes rises from the supra-sternal vessel; its volume is subject to great variations, and we have seen it entirely absent.

6. Inferior Cervical or Trachelo-muscular Artery (Fig. 375, 8, 8′).

Arising opposite the two preceding vessels, sometimes near the external, and at other times near the internal mammary arteries, this vessel is at first situated in the gulf between the jugulars, within the anterior superficial pectoral muscle, and above the glands at the entrance to the chest; it divides after a short course into two branches, which separate at a very acute angle. One of these, the *superior* (*ascending cervical* of Man), rises between the mastoido-humeralis and subscapulo-hyoideus muscles, to which it is distributed, as well as to the glands at the point of the shoulder, and the anterior superficial pectoral and angularis scapulæ muscles.

The *inferior branch* (*thoracica acromialis* of Man) descends in the interspace comprised between the mastoido-humeralis and the anterior deep pectoral muscles, accompanying the cephalic vein ; it is distributed to these two muscles, and superficial and anterior superficial pectorals.

7. Supra-scapular or Prescapular Artery (Fig. 375, 13).

This is a small and slightly tortuous vessel, which arises from the axillary artery, a little before it reaches the tendon of the subscapularis muscle. It is directed upwards, and enters the space included between that muscle and the supra-spinatus, after sending off some divisions to the anterior superficial pectoral muscle. Its terminal branches are expended in the inferior extremity of the supra- and infra-spinati muscles, the tendon of the biceps, and in the articulation of the shoulder.

8. Infra-scapular or Subscapular Artery (Fig. 376, 2).

This artery is remarkable for its considerable volume ; it arises at a right angle from the axillary artery, at the space separating the subscapularis from the teres major muscles. Its origin indicates the limit artificially fixed between the brachial trunk and the humeral artery. It is seen to proceed upwards and backwards in this interspace, within the caput magnum, until near the dorsal angle of the scapula, where it terminates.

It gives off on its track :

1. An artery which, following the inferior border of the latissimus dorsi muscle, ascends to its inner face, throwing off twigs into the substance of the muscle, as well as into the panniculus carnosus.

2. The *scapulo-humeral*, or *posterior circumflex artery of the shoulder*, which passes from within that articulation, beneath the caput magnum, to reach its external face. After giving off some collateral branches, it arrives, with the circumflex nerves, underneath the abductors of the arm, where it breaks up, like its satellite nerve, into several divergent branches destined to the three muscles above named, the oblique flexor and short extensor of the forearm, and to the mastoido-humeralis and panniculus carnosus.

3. *Muscular branches*, which escape at intervals during the course of the vessel, and are sent forwards and backwards. The *anterior* pass either to the internal or external side of the scapula, or to both sides of that bone, the posterior border of which they embrace in their bifurcation. The internal divisions creep in the fissures on the deep face of the bone, throwing their ramuscules into the subscapularis muscle, and even reaching the supra-spinatus, as well as the insertion of the angularis scapulæ and serratus muscles. The external divisions traverse the caput magnum, to be distributed to the supra- and infra-spinati and the abductor muscles of the arm—one furnishing the nutrient artery of the scapula. The *posterior branches* supply the abductor of the arm, and the caput magnum.

Humeral Artery, or Terminal Artery of the Brachial Trunk (Fig. 376).

Course.—This vessel is a continuation of the axillary artery, which changes its name after giving off the subscapular branch. At first it describes a slight curve forwards to descend almost vertically to the inside of the thoracic limb, by crossing obliquely the direction of the humerus, and terminates above the inferior extremity of that bone by two branches, which constitute the *anterior* and *posterior radial arteries.*

Relations.—In its course, the humeral artery is related: in front, to the median or ulno-plautar nerve, and to the posterior border of the coraco-humeralis muscle, which it closely follows; behind, to the vein of the arm, and through it to the ulnar nerve; outwardly, to the common tendon of the latissimus dorsi and the teres major, to the caput parvum, and to the humerus; inwardly, to the sheath of the biceps muscle, which separates the posterior deep pectoral from the artery of the arm, and in which this vessel is enclosed, in common with its satellite vein, the lymphatic glands and vessels of the arm, as well as with the nerves of the fore limb.

Collateral branches.—Among these may be distinguished four, which merit particular mention. They are the *prehumeral*, *external* and *internal collateral arteries of the elbow*, and the *principal artery of the flexor brachii muscle.* We need only indicate, besides these, several irregular ramuscules which go to the latter muscle, to the coraco-humeralis, and to the caput parvum.

1. *Prehumeral, or anterior circumflex artery* (Fig. 376, 4).—This arises at a right angle, is directed forward, passes between the two branches of the coraco-humeralis, turns round the anterior face of the humerus, beneath the bicipital groove, and terminates in the mastoido-humeralis muscle. During its progress it gives off branches to the coraco-humeralis and biceps muscles, as well as to the articulation of the shoulder. Among the articular ramifications, there is one which ascends outwardly on the tendon of the infra-spinatus; the ultimate divisions anastomose with the ramuscules of the posterior circumflex artery.

2. *Deep humeral* (*humeralis profunda*), *or external collateral artery of the elbow* (Fig. 376, 5).—A very large branch which emerges from the humeral trunk, by forming with that artery an almost right angle at the common terminal tendon of the latissimus dorsi and the teres major. After a very short course, it divides into two principal branches; one of these sends its ramuscules into the caput magnum and medium; the other passes under that muscle in turning round the humeralis obliquus, along with the radial nerve, and reaching beneath the caput medium, descends—still with its satellite nerve—in front of the articulation of the elbow, where this branch anastomoses with the anterior radial artery. It supplies all the olecranian muscles—except the caput magnum—as well as the humeralis obliquus and the extensor metacarpi magnus.

3. *Epicondyloid, internal collateral of the elbow* (*cubital*), *or ulnar artery* (Fig. 376, 7).—Smaller than the external collateral, this artery arises at the nutrient foramen of the humerus, and proceeds backwards on the internal face of that bone, to pass beneath the caput magnum, by following in a more or less flexuous manner the inferior border of the caput parvum; it then descends, at first behind the epicondyle, then on the forearm, which it passes along for its whole length, underneath the aponeurotic sheath of this region, between the flexor metacarpi medius and externus, accompanied by the ulnar vein and nerve of the same name, and the tendon of the ulnar portion of the perforans muscle. Arriving near the carpus, this long branch anastomoses by inosculation with a branch from the posterior radial artery.

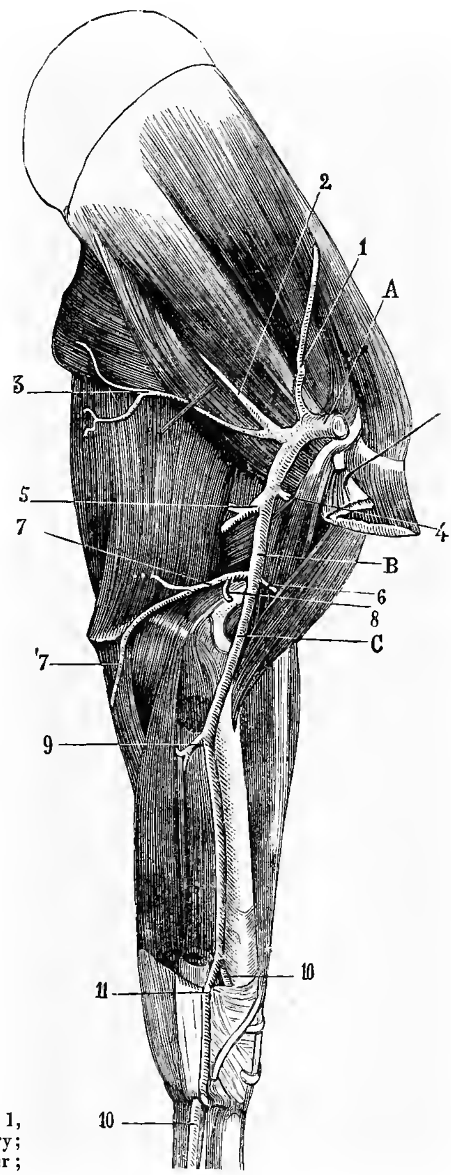
In its antibrachial course, this artery only gives off very attenuated branches, the study of which is of little importance. But before attaining the forearm, it furnishes: 1. The nutrient artery of the humerus. 2. Articular ramuscules. 3. More or less voluminous muscular branches, particularly for the caput magnum and medium, and superficial pectoral muscles. Those which arrive in the latter muscle traverse it only to become subcutaneous alternately; one of them accompanies the principal superficial vein of the forearm, and sends ramuscules into the bend of the elbow. Regular in their distribution, these different arteries present numerous varieties of origin, among which it is difficult to distinguish the most constant disposition. The last-mentioned vessel and the nutrient artery of the humerus, often emanate directly from the humeral trunk.

4. *Principal artery of the biceps, or coraco-radialis artery* (Fig. 376, 6).—This arises a little below or above the preceding; opposite to, or in front of it, it usually divides into two branches—one ascending, the other descending, which enter the substance of the muscle.

1. Anterior Radial (or Spiral) Artery (Figs. 376, 377).

The anterior radial artery, the smallest of the two terminal branches of the humeral, separates at an acute angle from the posterior artery, above the articular condyle of the humerus. It descends on the anterior face of the ulnar articulation, passing beneath the inferior extremity of the flexor muscles of the forearm and the superior extremity of the extensor metacarpi, where it meets the radial nerve; in company with this nerve, it extends on the anterior face of the radius, below the extensor metacarpi magnum, to the knee, where it becomes very thin and breaks up into several ramuscules, which are continued on

Fig. 376.



TERMINATIONS OF THE AXILLARY ARTERY IN THE HORSE.

A, Axillary portion of the brachial trunk. 1, Supra-scapular artery; 2, infra-scapular artery; 3, branch to the latissimus dorsi from the latter; 4, prehumeral or anterior circumflex artery; 5, humeralis profunda; 6, principal artery of the biceps; 7, internal collateral or cubital artery; 7′, the point where it becomes the ulnar; 8, nutrient artery of the humerus. C, Posterior radial artery at its origin. 9, Muscular branch of the posterior radial artery; 10, 10′, collateral of the cannon, one of the terminal branches of the posterior radial; 11, vessel common to the interosseous metacarpals, another branch of the posterior radial artery.

the capsular ligament of the carpal articulations, after anastomosing on the inner side with the divisions of a branch furnished by the posterior radial artery, and on the outside with the ramifications from the interosseous artery of the forearm.

These terminal ramuscules are distributed to the carpal articulation, or the sheaths of the extensor tendons, and communicate with the dorsal interosseous metacarpal arteries.

The collateral branches given off by this artery are very numerous, the majority of them being detached from the superior portion of the vessel, near the elbow; they are intended to supply that articulation, but more especially the muscular masses lying in its neighbourhood, or covering it.

Such is the usual disposition of the anterior radial artery; though it is liable to numerous variations—principally in the manner in which it comports itself with the interosseous artery of the forearm, which may even supplement it for the whole of the middle and lower part of its course. This will be noted in describing the next artery.

2. Posterior Radial Artery (Fig. 377, 1).

This vessel, in its volume and direction, represents the continuation of the humeral artery. It descends, along with the ulno-plantar nerve, on the internal ligament of the humero-radial articulation, behind the terminal extremity of the biceps; then under the internal flexor of the metacarpus, its satellite muscle. Arriving at the inferior extremity of the radius, it divides into two terminal branches; these are the *common trunk of the interosseous metacarpal arteries*, and the *collateral (large metacarpal) artery of the cannon*.

The following are the principal collateral branches furnished by the posterior radial artery :—

1. At the superior extremity of the radius, articular ramuscules which anastomose with analogous branches from the ulnar artery.

2. A little lower, large divisions destined for the muscles of the posterior antibrachial region, some of them arising from the next artery.

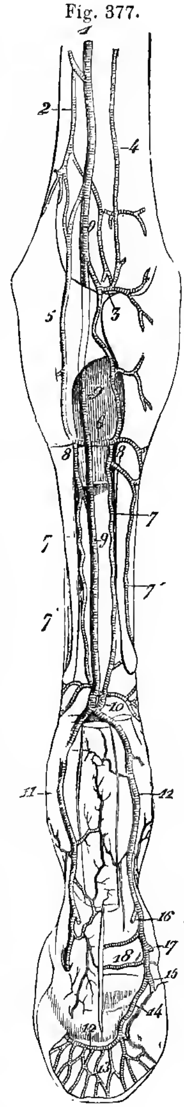
3. The *interosseous artery of the forearm*, a considerable vessel which arises at the same point as the preceding—the radio-ulnar arch, and crosses this from within to without, after traversing the posterior face of the radius, beneath the perforans muscle, to descend along the extensor suffraginis, in the channel formed outwardly by the union of the two bones of the forearm. This interosseous artery furnishes, immediately after its exit from the radio-ulnar arch, several branches to the articulation of the elbow and the antibrachial muscles. At its terminal extremity it usually divides into a number of branches, the majority of which join the branches sent to the carpus by the anterior radial artery. It is rare that it does show some fine anastomoses with one of the divisions of the latter artery in front of, or outside the articulation of the elbow; sometimes it directly joins that vessel; and we have seen it, on the contrary, receive the anterior radial artery, which it in part supplanted.

4. Several muscular and musculo-cutaneous ramuscules without any fixed arrangement, arising from different points of the course of the parent artery, below the preceding divisions.

5. A deep branch, also liable to very numerous variations, having its origin at the radial insertion of the perforatus muscle, descending on the posterior face of the radius, chiefly destined to the carpus, and remarkable for the anastomoses

that its internal divisions form with the anterior radial artery, and for those which occasionally unite its external ramifications to the ultimate branches of the interosseous artery of the forearm or the ulnar artery (Fig. 377, 2).

Fig. 377.



1. First Terminal Branch of the Posterior Radial Artery (Radio-palmar), or Common Trunk of the Interosseous Metacarpal Arteries[1] (Figs. 376, 5; 377, 3).

This arterial branch separates at a very acute angle from the collateral artery of the cannon. It descends inside and behind the carpus, accompanied by the principal subcutaneous vein of the limb, and with it is included underneath a superficial fascia, which maintains them in a channel hollowed on the external face of the carpal fibrous sheath. It thus arrives within the head of the inner metacarpal bone, where it is inflected to the outer side by crossing the superior extremity of the suspensory ligament, and between it and the metacarpal ligament the latter furnishes to the perforans tendon; it anastomoses by inosculation with a descending branch which emanates from the superficial arch that, above the carpus, unites the ulnar artery to the origin of the collateral artery of the cannon (Fig. 376). The loop-like anastomosis thus formed by the radio-palmar artery exactly corresponds to the *deep palmar arch* of pentadactylous animals, particularly to that of Man. We propose to name it also the *infra-carpal arch*, by reason of the position it occupies with regard to the carpus; reserving the appellation of *supra-carpal arch* for the *superficial palmar arch*, which is represented by the anastomosis established between the collateral artery of the cannon and the ulnar artery.

Four principal branches emanate from this infra-carpal arch: these are the *metacarpal interosseous arteries*, distinguished as *posterior* or *palmar*, and *anterior* or *dorsal*.

a. The *posterior interosseous* arise, one on the right, the other on the left, at the head of the lateral metacarpal bones, each descending on its own side and in a flexuous manner, along these rudimentary bones, in the angular groove formed

ARTERIES OF THE FORE FOOT, SEEN FROM BEHIND.

The muscles and tendons have been removed, only a small portion of the perforans tendons being left; the os pedis has been chiselled away on its plantar face to expose the semilunar anastomosis.

1, Posterior radial artery; 2, innominate carpal branch; 3, supra-carpal arch; 4, ulnar artery; 5, radio-palmar artery, or common trunk of the interosseous metacarpal arteries; 6, infra-carpal arch; 7, 7, posterior interosseous metacarpal arteries; 7′, 7′, anterior interosseous metacarpal arteries; 8, 8, their origin; 9, collateral artery of the cannon; 10, its communicating branch with the interosseous arteries; 11, 11, digital arteries; 12, semilunar anastomosis in the os pedis; 13, emergent branches of this anastomosis; 14, plantar ungual artery, forming the anastomotic arch; 15, origin of the preplantar ungual artery; 16, origin of the plantar-cushion artery; 17, origin of the anterior branch of the coronary circle; 18, posterior branch of the same.

[1] This vessel corresponds to the *radio-palmar artery* of Man, by which name it is sometimes designated. Rigot has improperly named it the *deep plantar artery*.

by their inner face and the posterior face of the principal metacarpal bone, terminating at the inferior extremity of the lateral bones, by anastomosing in full canal with a branch of the collateral of the cannon. They furnish some ramifications to the suspensory ligament which covers them, and several tendinous and cellulo-cutaneous twigs; one supplies the nutrient artery of the large metacarpal bone (Fig. 377, 7).

b. The *anterior interosseous arteries* arise from nearly the same point as the preceding—one outwards, the other inwards—turning back round the head of the lateral metacarpals to place themselves in the groove which separates these from the large metacarpal bone, on their external or dorsal face, after having thrown off several anastomosing ramuscules that communicate between the two arteries in front of the upper extremity of this bone, or with the terminal branch of the anterior radial and the interosseous arteries of the forearm. By their terminal extremity, these two arteries anastomose with a branch of the collateral of the cannon—that which receives the posterior interosseous arteries (Figs. 376, 7; 377, 11).

The dorsal interosseous arteries, although much finer than the palmar—in Solipeds these arteries are quite rudimentary—nevertheless furnish collateral divisions for the anterior tendons of the metacarpus, the periosteum, the connective tissue, and the skin. They often communicate with the posterior arteries by deep branches, which cross the intermetacarpal ligaments.

Variations.—The existence of the interosseous metacarpal arteries, their position, and their anastomoses with the inferior extremity of the collateral of the cannon, are constant; though this is not the case with regard to their origin, or the source whence they are derived. In the typical description given, we have considered them all as being furnished by the radio-palmar artery; but it is necessary to add that one of the four—the external dorsal—often comes directly from the arterial branch that, from the *supra-carpal arch*, descends along the carpus to concur in forming the *infra-carpal arch*, by anastomosing with the radio-palmar, or rather with a branch of the interosseous of the forearm. It is also necessary to add that these metacarpal arteries sometimes arise together from one large branch furnished by the collateral of the cannon, at the superior extremity of the metacarpus (Fig. 377), and which receives the now rudimentary radio-palmar artery, as well as that given off by the supra-carpal arch; so that we may have two superposed supra-carpal arches. We have met other anomalies which need not be noticed here, as they are without interest.

2. Second Terminal Branch of the Posterior Radial, or Collateral Artery of the Cannon[1] (Figs. 376, 9; 377, 2).

The collateral artery of the cannon (or large metacarpal artery) (Fig. 376, 9) continues by its volume and direction, the posterior radial artery. It passes, with the flexor tendons, under the carpal arch, and descends on the inner side of these tendons, accompanied by the internal plantar nerve, to above the fetlock and near the sesamoid bones, where it bifurcates into the *digital arteries*.

Collateral branches.—We observe:

1. Near the origin of the artery, and very often from the posterior radial artery itself, a branch which anastomoses above the pisiform bone with the ulnar artery, forming an arch, the convexity of which is inferior (Figs. 376, 10; 377,

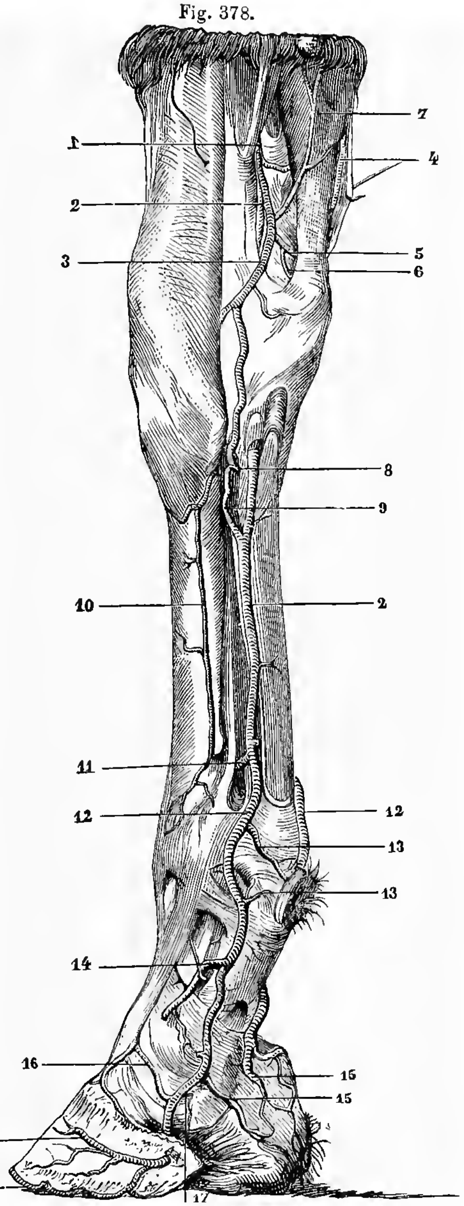
[1] This artery, the *superficial plantar* of Rigot, represents one of the *metacarpal palmar branches* furnished by the superficial palmar arch in Man and other pentadactylous animals.

11), and which has been already noticed as the *supra-carpal* or *superficial palmar arch*, in contradistinction to the *infra-carpal* or *deep palmar arch*—the source of the interosseous arteries of the metacarpus. This ramification furnishes one or more muscular arterioles that usually anastomose with the other branches of the posterior radial artery; and an inferior division,[1] which descends in the carpal arch, within the pisiform bone, to the superior extremity of the metacarpus, where it inosculates with the radio-palmar artery, after detaching several carpal ramuscules, the principal of which winds round the inferior border of the pisiform bone.

2. On its course, numerous and fine synovial, tendinous, and cutaneous divisions.

3. A trunk springing from the terminal extremity of the vessel, between the two digital arteries, sometimes even from one of these, which is placed at the posterior face of the principal metacarpal bone, within the two branches of the suspensory ligament, and, passing upwards, soon divides into two branches; these anastomose by inosculation with

Fig. 378.



ARTERIES OF THE ANTERIOR FOOT OF THE HORSE.

1, Posterior radial artery; 2, 2, collateral of the cannon; 3, trunk common to the interosseous metacarpals; 4, ulnar artery; 5, supra-carpal arch; 6, descending branch from the arch to form the infra-carpal arch; 7, arteriole for the ergot from the trunk common to the interosseous metacarpals; 8, infra-carpal arch; 9, branch of the collateral of the cannon concurring, in this preparation, in the formation of the interosseous metacarpals; 10, a dorsal interosseous metacarpal artery; 11, communicating branch of the collateral of the cannon with the interosseous metacarpals; 12, 12, digital arteries; 13, 13, arterioles of the ergot; 14, perpendicular artery—one of its branches to the circumflex artery of the coronet, has been excised on removing the lateral cartilage; 15, 15, arteries of the plantar cushion; 16, anterior part of the coronary circle; 17, posterior part of ditto; 18, preplantar ungual artery; 19, inferior circumflex artery of the foot.

[1] Analogous to the *radio-ulnar artery* of Man.

the posterior interosseous arteries of the metacarpus, after giving off on each side two other ramuscules that wind round the borders of the large metacarpal bone, receiving the dorsal interosseous arteries, and ramify in front of the fetlock, on the anterior face of the cannon bone, and in the texture of the capsular ligament of the metacarpo-phalangeal articulation (Figs. 376, 10; 378, 11).

Terminal branches.—These are, as we said, the *digital arteries*, which almost exactly repeat the disposition of these vessels in the posterior limb, and which have been described at p. 636.

Differential Characters in the Axillary Arteries of the other Animals.

1. Axillary Arteries of Ruminants.

These vessels comport themselves in their origin, course, and relations, as in Solipeds. The special characters they present in their distribution are as follows:—

1. *Dorsal artery.*—This arises from a trunk common to it and the vertebral artery, and usually leaves the thorax by passing above the first costo-vertebral articulation. Its *subcostal branch* proceeds directly from the above-named trunk.

2. *Superior cervical artery.*—This is absent, and is replaced by a branch of the dorsal artery, but particularly by the superior muscular divisions of the vertebral artery.

3. *Vertebral artery.*—Extremely voluminous, and terminates in the muscles of the neck, after passing through the foramen of the axis; it is remarkable for the considerable size of its spinal branches.

4. *Inferior cervical, and internal and external thoracic arteries.*—These do not present anything worthy of special consideration, except that the last is very voluminous in the **Ox** and very slender in the **Sheep**, and supplies the satellite arterial branch of the cephalic vein, which, in Solipeds, arises from the inferior cervical artery.

5. *Supra-scapular artery.*—This vessel appears to us to be absent in the **Sheep**, and its place supplied by the divisions of the inferior cervical artery.

6. *Subscapulary artery.*—The *scapulo-humeral* branch gives off the majority of the branches for the posterior brachial muscles.

7. *Humeral artery.*—The muscular arteries are of small size, particularly the deep humeral, which is largely replaced by the scapulo-humeral branch.

8. *Anterior radial artery.*—This comports itself similarly to that of the Horse, and is liable to as frequent anomalies.

9. *Posterior radial artery.*—This artery follows the same course as in Solipeds; only instead of furnishing the *radio-palmar artery* near the carpus, at the point where it becomes the *collateral artery of the cannon*, it gives off that vessel much higher, and near the upper third or middle of the forearm. Its *interosseous branch*, lodged in the deep channel on the outside of the bones of this region, where the radius and ulna join, is separated into two branches near the inferior extremity of that groove. The anterior of these ramifies on the dorsal face of the carpus, and anastomoses with the division of the anterior radial artery; the posterior traverses the inferior radio-ulnar arch, to distribute the majority of its branches behind the carpal articulations.

10. *Radio-palmar artery.*—Arising, as we have already seen, from the posterior radial artery, towards the upper third of the forearm, this branch descends to the superior extremity of the metacarpus in following, as in the Horse, a superficial course, and ends in four *metacarpal interosseous orteries: three posterior* or *palmar*, and *one anterior* or *dorsal*. The *posterior interosseous* arteries are very irregular and inconstant in their disposition; they communicate with each other by several branches, and anastomose, inferiorly, either with the lateral digital arteries, the collateral of the cannon, or, as is most commonly the case, with a branch of the latter vessel. These interosseous arteries are distinguished into external, middle, and internal; the first two are comprised between the posterior face of the metacarpus and the suspensory ligament; the third, placed at the inner border of that ligament, is more considerable than the others, and by its volume and direction represents the continuation of the radio-palmar artery. The *anterior interosseous* artery passes through the foramen at the superior extremity of the metacarpus, and, arriving at the dorsal face of the bone, bifurcates, its ascending branch reaching the capsular ligament of the carpal articulations, where it anastomoses with the divisions of the anterior radial and interosseous arteries of the forearm; the descending is lodged in the anterior groove of the metacarpal bone, and joins a perforating branch of the

collateral artery of the cannon—a branch that crosses the foramen towards the inferior extremity of the bony diaphysis. If it is desired to ascertain the signification of these interosseous arteries, in their relation to the elements composing the foot of Ruminants, we readily recognize: in the posterior median artery, the interosseous palmar of the two great digits; in the posterior lateral arteries, the interosseous palmar, intermediates to these middle digits, and the rudimentary lateral digits represented by the ergots, or dew claws; and in the single anterior artery, the dorsal interosseous of the two great digits. We may even prove, by a more minute examination, the existence of dorsal interosseous arteries corresponding to the lateral palmar interosseous vessels.

11. *Collateral artery of the cannon.*—This artery follows the same track as in the Horse, as far as the lower third or fourth of the metacarpus. Arrived at this point, it gives off—as in the Horse—a branch the divisions of which communicate with the interosseous arteries, and are continued by the digital arteries, three in number—a middle and two lateral.

a. The *communicating branch with the metacarpal interosseous arteries*, very often arises from the internal digital artery.

It is insinuated between the divisions of the suspensory ligament, and ascends on the posterior face of the metacarpus, breaking up into a number of branches which nearly all join the precited arteries, or even the lateral digital, in having a variable and complicated arrangement which it is needless to notice here. One of these branches—a true *perforating artery*, traverses the inferior extremity of the cannon bone, and ascends in its anterior groove to join the anterior interosseous artery, after detaching ramuscules to the metacarpo-phalangeal articulation.

b. The *middle digital artery* represents, in its dimensions, the continuation of the collateral artery of the cannon, and is a very voluminous vessel. It is at first inflected backwards and outwards, to be placed on the posterior face of the perforatus tendon; then it descends into the interdigital space by passing behind the sesamoid bursa, beneath the ligament uniting the two claws. Reaching the inferior extremity of the first phalanx, it divides into two *ungual arteries*—one for each digit, which are inflected forwards, pass beneath the internal ligament common to the two interphalangeal articulations, and enter by the foramen at the inner side of the pyramidal process, into the internal sinus of the third phalanx, where each ramifies in the same manner as the plantar ungual arteries of the Horse.

Several collateral branches, remarkable for the richness of their arborizations, escape from this median artery of the digits and its terminal divisions. The most important of these are: 1. At the middle of the first phalanx, two short transverse branches—a right and left, passing beneath the flexor tendons, and going from the median digital artery to the lateral arteries of the digits. 2. Nearly at the same point, a single artery which traverses the interdigital space from behind to before, to pass between the two tendons of the common extensor of the phalanges, whence it ramifies on the anterior face of the digits by ascending alongside the anterior median vein, and anastomosing with a descending branch of the perforating artery which crosses the inferior extremity of the metacarpus. 3. A double branch analogous to the artery of the plantar cushion of the Horse, having its origin at the terminal extremity of the digital artery, often arising from the ungual artery, either on one side or both, and communicating, by a transverse branch, with its homologue; it is directed backward and downward on the bulb of the heel, where it forms an anastomotic arch with the lateral digital artery; from the convexity of this arch, which is turned downwards, there escapes a large number of reticulating ramuscules, which go to the keratogenous membrane and the plantar cushion.

c. The *lateral digital arteries* are distinguished into *internal* and *external.* The first has its origin at the bend formed by the collateral of the cannon, when that vessel is inflected on the posterior face of the perforatus tendon to become the median digital artery, most frequently in common with the branch the divisions of which join the metacarpal interosseous arteries. The second commences a little further off, after having received a branch from either this communicating artery, or from the external interosseous palmar; it is not rare to see it entirely formed by one of these branches, or by the two together. Whatever may be their point of origin, the lateral digital arteries descend on the eccentric side of the digits, outside the flexor tendons, and terminate in anastomosing by inosculation with the artery of the plantar cushion. Among the collateral branches emanating from these arteries, there ought to be distinguished that which goes to the ergot, and the transverse branch thrown across between each, as well as the median digital artery.[1]

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[1] In several instances, we have seen the lateral digital arteries stop at this transverse anastomosis, which then received them entirely.

2. Axillary Arteries of the Pig.

Both spring separately from the arch of the aorta: consequently, there is no anterior aorta. The *right axillary artery*, or *brachio-cephalic trunk*, first arises; the *left* comes immediately after.

a. The *right axillary artery* is directed forwards, under the inferior face of the trachea, and leaves the thorax to reach the inner face of the anterior limb, as in other animals.

It furnishes successively:—

1. At the first rib, and below, the two *carotid arteries*, rising singly from nearly the same point.

2. Directly opposite to these vessels, a trunk remarkable for the complexity of its distribution; it is directed upwards and backwards, on the side of the trachea and longus colli, crosses the interval between the second and third ribs, and rises to the deep cervical muscles to terminate in the vicinity of the nape of the neck. It evidently represents the *deep* or *superior cervical artery*. Near its origin it gives off the *vertebral artery*, the termination of which is exactly the same as in the Horse. Beyond this, it detaches the *dorsal artery*, which ascends into the muscles of the withers, after passing into the first intercostal space. Lastly, it supplies, before leaving the thorax, the *subcostal* or *superior intercostal artery*, placed across the superior extremities of the third, fourth, and fifth ribs.

3. Always within, but a little more forward than the first rib, a voluminous *inferior cervical artery*, divided into several ascending branches; and the *two thoracic arteries*, which offer nothing particular for description.

4. Outside the thorax, on the internal face of the scapulo-humeral articulation, the *humeral* or *subscapular arteries*. The first, less voluminous than the other, presents, from its origin to the distribution of its branches in the foot, a disposition essentially resembling that observed in this vessel in Ruminants; the second courses upwards in the space between the subscapularis and the teres major, and soon divides into two terminal branches, one of which continues the course of the vessel, while the other passes beneath the subscapularis muscle to carry its ramifications into the antero-external muscles of the shoulder, furnishing in its course: (1) The great dorsal artery, throwing a part of its ramifications into the olecranian muscles. (2) A voluminous branch that provides the greater number of the divisions given off, in the Horse, by the deep humeral and prehumeral arteries. (3) Two articular branches, one of which closely represents the supra-scapular artery.

b. The *left axillary artery* only differs from the right in the disposition of the *superior cervical*, *dorsal*, and *vertebral* arteries, which have distinct origins; the two last are very close to each other, and the first furnishes the *subcostal branch*.

3. Axillary Arteries of Carnivora.

These arise separately from the convexity of the arch of the aorta, as in the Pig, and furnish successively, besides the carotids, special branches of the axillary artery trunk:—

1. A voluminous trunk, the common origin of the *dorsal*, *superior cervical*, and *subcostal* or *superior intercostal* arteries. The first passes between the two anterior ribs; the second in front of the first; the third across the internal face of the first, second, and third ribs, near their cartilages, where it emits ascending and descending intercostal branches.

2. The *vertebral artery*, anastomosing, as in Solipeds, with a retrograde branch from the occipital artery; it supplements, in very great part, the superior cervical, the volume of which is diminutive; it is only distributed to the superior part of the neck.

3. The *inferior cervical artery*, giving off the pectoral branches.

4. The *internal thoracic artery*, remarkable for its large volume, and for a superficial division chiefly destined to the mammæ, which joins an analogous branch from the external pudic artery.

5. An *external thoracic* branch, the origin of which more resembles that of the *supra-scapular artery*, which appears to be absent.

6. The *subscapular artery*.—After furnishing this vessel, the axillary is continued by the humeral artery, which we will now examine in detail.

Humeral Artery.—Placed at first immediately behind the biceps muscle, this vessel descends beneath the pronator teres, and divides at the superior extremity of the radius into two terminal branches—the *ulnar* and *radial arteries*.

It detaches on its course collateral branches, analogous to those which have been described for Solipeds, and among which is a thin vessel—a vestige of the *anterior radial artery*, that passes beneath the terminal extremity of the biceps to supply the muscles covering, anteriorly, the articulation of the elbow.

Ulnar artery.—Much smaller than the radial, this vessel gives off, near its origin, the *interosseous artery*, which sometimes proceeds directly from the humeral artery, and the calibre of which always exceeds, in animals, that of the ulnar artery. The latter is directed obliquely outwards and downwards, passing under the perforans, and gains the internal face of the anterior ulnar or oblique flexor of the metacarpus, where it lies beside the ulnar nerve, to descend with it inside the uniform bone, and join the posterior interosseous artery, or one of its terminal branches. On its track it gives off a number of muscular or cutaneous branches, several of which anastomose with the internal collateral artery of the elbow, as well as with divisions of the radial artery.

Interosseous artery.—This artery is placed between the ulna and radius, underneath the pronator quadratus, and is prolonged to the lower third of the forearm, where it separates into two branches—the *anterior* and *posterior interosseous arteries*, after throwing off on its way several branches, mostly anterior, which enter the antibrachial muscles by traversing the space comprised between the two bones of the forearm, the principal escaping by the radio-ulnar arch.

The *anterior interosseous artery*, after passing between the radius and ulna, descends on the anterior face of the carpus, where its divisions meet, inwardly, the collateral ramuscules of the radio-palmar artery, and outwardly, the arborizations of a branch from the posterior interosseous artery, forming with these vessels a wide-meshed plexus, from which definitely proceed several filaments that join the dorsal interosseous metacarpal arteries.

The *posterior interosseous artery* may be regarded, by its volume and direction, as the continuation of the interosseous trunk. After emerging from beneath the pronator quadratus, it detaches an internal flexuous branch anastomosing with the radio-palmar artery, then several external musculo-cutaneous branches; after which it is placed within the pisiform bone, where it divides into two branches, after receiving the ulnar artery. The smallest of these branches anastomoses by inosculation with the superficial palmar arch; the other, larger and deeper seated, is carried in front of the flexor tendons, beneath the aponeurosis covering the interosseous muscles, across the superior extremity of these, and so forming the *deep palmar arch*, which unites with a thin filament from the radio-palmar artery. This arch supplies, with some ramuscules destined to the muscles of the hand (or paw), *eight interosseous metacarpal arteries*—*four posterior* or *palmar*, which are united by their inferior extremity with the collaterals of the digits, after giving several divisions to the muscles of the hand; and *four anterior* or *dorsal*, traversing the superior extremity of the intermetacarpal spaces, like the *perforating arteries* in Man, joining the anterior interosseous branches of the forearm, and descending afterwards into the intermetacarpal spaces, to unite with the collateral arteries of the digits at the metacarpo-phalangeal articulations.

Radial artery—the *posterior radial* of the other animals. Lying alongside the long flexor of the thumb and the perforans muscle, this artery follows the inner face of the perforatus muscle, and curving outwards to be united to a branch from the posterior antibrachial interosseous artery, forms the *superficial palmar arch*, from which escape four branches—the *palmars* or *collaterals of the digits*. These are at first situated between the perforatus and perforans tendons, and reach the superior extremity of the interdigital spaces, where they receive the metacarpal interosseous arteries, and comport themselves in the following manner: the *internal* goes to the thumb; the *second*—counting from within outwards—gains the concentric side of the index; the *third*, the largest, divides into two branches which lie alongside the great digits; the *last* goes to the external digit.

Comparison of the Axillary Arteries in Man with those of Animals.

The arteries of the thoracic limbs and head arise separately from the arch of the aorta; consequently, in *Man* there is no anterior aorta.

The vessel of the limb that represents the axillary of animals is here resolved into two portions: the *subclavian artery* and *axillary artery*.

The **Subclavian Artery** has not the same origin on both sides; on the right it arises from the aorta by a trunk common to it and the carotid of that side—the *arteria innominata*; while the left is detached separately from the most distant part of the aortic arch. The subclavian vessels extend to the inferior border of the clavicles, and furnish seven important collateral branches, which are present in the domesticated animals. They are—

1. The *vertebral artery*, situated in the vertebral foramina of the cervical vertebræ, as far as the axis; there it anastomoses, as in Solipeds, with a branch of the carotid, enters the spinal canal by the foramen magnum, and unites with its fellow at the lower border of the pons Varolii to form the basilar artery which, in the Horse, comes from the cerebro-spinal artery of the occipital.

2. The *inferior thyroid*, the origin of which, and some branches, we find in the ascending branch (*ascending cervical*) of the inferior cervical artery in the Horse.

Fig. 379.

ARTERIES OF THE HUMAN FOREARM.

1, Lower part of biceps; 2, inner condyle of humerus; 3, deep portion of pronator radii teres; 4, supinator longus; 5, flexor longus pollicis; 6, pronator quadratus; 7, flexor profundus digitorum; 8, flexor carpi ulnaris; 9, annular ligament; 10, brachial artery; 11, anastomotica longus magna, inosculating above with the inferior profunda, and below with the anterior ulnar recurrent; 12, radial artery; 13, radial recurrent, inosculating with the superior profunda; 14, superficialis volæ; 15, ulnar artery; 16, superficial palmar arch, giving off digital branches to three fingers and a half; 17, magna pollicis and radialis indicis; 18, posterior ulnar recurrent; 19, anterior interosseous; 20, posterior interosseous.

3. The *internal mammary* artery divides into two branches at the xiphoid cartilage of the sternum.

4. The *superior intercostal artery*, the analogue of which we see in Solipeds, in the subcostal branch of the dorsal.

5. The *supra-scapular artery*, present in all animals and disposed in the same manner.

6. The *transverse cervical* (*transversa colli*), represented by the extra-thoracic branches of the dorsal artery.

The Axillary Artery, or extra-thoracic portion of the subclavian trunk, extends to the external border of the pectoral muscle, where it is continued by the humeral artery. The axillary gives off: the *thoracica acromialis*, resembling the descending branch of the inferior cervical artery of large quadrupeds; the *external mammary; subscapular;* and *posterior* and *anterior circumflex*, branches of the preceding in Solipeds.

Humeral (Brachial) Artery.—This artery extends from the external border of the pectoral muscle to the bend of the elbow: here it divides into two terminal branches—the ulnar and radial.

In its course it gives off several muscular branches, and an *external* and *internal collateral of the elbow* (*collateralis ulnaris superior* and *inferior*). In the lower third of the arm, the brachial artery is comprised between the brachialis anticus and inner border of the biceps; so that, during flexion, and especially active and forced flexion, of the forearm on the arm, in vigorous subjects, the circulation is arrested in the vessels of the hand.

The *radial artery* of Man is represented in the Horse by the posterior radial artery. It is directed downward and a little inward, supposing the hand to be in a state of pronation; it crosses the carpus in front of the trapezium and scaphoides, at the bottom of the anatomical snuff-box, and beneath the flexor tendons of the phalanges forms the *deep palmar arch*, finally anastomosing with a branch of the ulnar at the hypothenar eminence. Along its course it furnishes muscular branches: the *carpea anterior; radio-palmar*, which passes outwards, and unites with a branch of the ulnar artery to form the *superficial palmar artery;* the *dorsalis pollicis;* the *carpea posterior*, which concurs in the formation of the *dorsal arch of the carpus*, that gives origin to the *dorsal interosseous branches*.

The *ulnar artery*, formed, in Solipeds, by the anterior radial, passes downward and outward; it is at first covered by the great pronator muscles, great and small palmar, and superficial flexor; lower, it is only protected by the antibrachial aponeurosis and the skin. On the anterior face of the carpus, it passes within the pisiform bone, and anastomoses with the radio-palmar artery; whence results the superficial palmar arch. It gives rise to two *recurrent* arteries that ascend to receive the collateral vessels of the elbow, then to a trunk seen in animals, and which divides into the *anterior* and *posterior interosseæ*.

The three arches in the vicinity of the carpus, the constitution of which has been already given, are distributed in the following manner:—

The *superficial palmar arch* is situated at the surface of the flexor tendons; from its convexity it emits four or five metacarpal branches: the first reaches the external border of the little finger as the *external collateral* of that organ; the other four are lodged in the interosseous spaces, and when they reach the roots of the fingers they bifurcate and form the *external* or *internal collateral arteries* of the five fingers. The *deep palmar arch* furnishes: articular branches to the wrist, the *perforating branches* which cross the interosseous spaces to unite with the dorsal interosseæ; the *palmar interosseæ*, which join the superficial interosseæ before their division into collateral branches. Lastly, the *carpal dorsal* arch gives off the *dorsal interosseæ*, which receive perforating filaments above and below the metacarpus, and are expended in the articulations and skin of the fingers.

Article VII.—Common Carotid Arteries (Figs. 375, 14; 381, 1).

These two vessels (named from κάρα, the head)[1] arise from the right axillary artery, at a short distance from its origin, by a common trunk—the *cephalic artery*—which is detached at a very acute angle, and is directed forward beneath the inferior face of the trachea, and above the anterior vena cava, to terminate near the entrance to the chest by a bifurcation that commences the two common carotids—right and left.

Each of these arteries afterwards ascends in a sheath of connective tissue, along the trachea, at first beneath that tube, then at its side, and finally a little above its lateral plane. Each carotid arrives in this way at the larynx and guttural pouch, where it divides into three branches.

In its course, this vessel—independently of the connection between it and the trachea—has the following relations:—

Throughout its entire length, it is accompanied by the cord that results from the union of the pneumogastric nerve with the cervical portion of the sympathetic, and by the recurrent nerve; the latter is placed below or in front of the vessel, from which it is somewhat distant in the lower part of the neck; the first is situated above or behind the artery, and lies close to it.

It is also related: behind, in its upper two-thirds, to the longus colli and the rectus capitis anticus major; outwardly, to the scalenus towards the inferior extremity of the neck, and to the subscapulo-hyoideus, which separates the artery and jugular vein in the middle and upper part of the neck. But near the entrance to the chest these two vessels are in direct relationship—the vein below and the artery above.

It is also to be noted, that the glands at the entrance of the chest are in contact with the carotids, and that the left artery is related, besides, to the œsophagus.

Collateral Branches.—The branches furnished by the common carotid on its course are somewhat numerous, but they are of such inconsiderable diameter that their successive emission does not sensibly vary the calibre of the vessel from which they emanate; so that the carotids represent, from their origin to their termination, two somewhat regular cylindrical tubes. These collateral branches are destined either to the muscles of the cervical region, or to the œsophagus and trachea. Two of them—the *thyro-laryngeal* and *accessory thyroid arteries*—will occupy us in a special manner.

Thyro-laryngeal Artery (Fig. 381, 14″).—This vessel, which corresponds exactly to the *superior thyroid artery* of Man,[2] arises from the common carotid at a short distance from its termination, a little behind the larynx or above the thyroid body; it passes on that organ, into which it enters by two principal branches that turn round its superior extremity and anterior border, after sending two branches to the larynx—a superior, also for the pharyngeal walls; and

[1] Baillet has remarked that the two common carotid arteries have not the same calibre in the Horse.

[2] We would have given it the same name if we could have found the true representative of the *inferior thyroid artery*.

an inferior, much more considerable, exclusively distributed to the laryngeal apparatus. The latter passes between the cricoid and the posterior border of the thyroid cartilage, on the internal surface of which it sends off several ramuscules, some of which pass forwards, others backwards—the latter spreading over the ventricle of the glottis and the thyro-arytænoid muscle, to become expended in the arytænoid muscle. The superior branch for the pharynx, also supplies the crico-arytænoideus.

It sometimes happens that the thyro-laryngeal artery is found divided at its origin into two quite distinct branches, each furnishing a laryngeal and a thyroid division, as in Fig. 381, 3.[1]

We have already remarked on the disproportion existing between the considerable calibre of the branches sent by this artery to the thyroid body, and the slender volume of that organ; so that it will at present suffice to remind the student of this peculiarity.

Accessory Thyroid Artery (Figs. 375, 14′; 381, 2).—The origin of this vessel precedes that of the first; it is much smaller, and enters the thyroid body by the posterior or inferior extremity of this glandiform lobe.

This artery often sends only some excessively fine ramuscules to the thyroid body, and expends itself almost entirely in the cervical muscles.[2]

TERMINAL BRANCHES.—The three branches which terminate the common carotid are the *occipital*, and *internal* and *external carotid arteries*; the latter is incomparably larger than the other two, which only appear to be collateral offshoots from the principal vessel. It is these branches which distribute the blood to the various parts of the head. We will devote three special paragraphs to their study; but their preparation will previously demand some notice.

Preparation of the arteries of the head.—After carefully removing the skin, dissect the superficial arteries of one side—that is, the external maxillary, maxillo-muscular, the temporal trunk, and the posterior auricular arteries—excising the parotid gland to expose the origin of the three last-named vessels. On the opposite side, the deep arteries are prepared, after disposing of the branch of the inferior maxilla, as in the PREPARATION OF THE MUSCLES OF THE TONGUE; the orbital and zygomatic processes being removed in three sections with the saw, as in Fig. 381, which will serve as a guide in the dissection of all these arteries.

It is possible to prepare all the arteries on one side; and in order to do this, a commencement should be made by dissecting the superficial branches; after which, these are cut in the middle of their course and the first half thrown back on the parotid. The facial is left intact. The deep arteries are reached by dividing and disposing of the inferior maxilla, as was directed in the second procedure in preparing the muscles of the tongue and pharynx.

Occipital Artery (Fig. 381, 6).

The occipital artery is a slightly flexuous vessel, lying alongside the upper third of the internal carotid. It ascends beneath the transverse process of the atlas, in passing behind the guttural pouch, between the maxillary gland and the straight anterior muscles of the head. It then insinuates itself between the rectus capitis lateralis and the inferior arch of the above-named vertebra, to pass through its anterior foramen, and terminate by two branches, after coursing along the short fissure that unites this foramen with the superior foramen. In

[1] It was doubtless a case of this kind that Rigot had before him when he described the above vessel, and made two arteries of it—the *thyroid* and *laryngeal*. But, we repeat, this is only an exceptional instance, and does not authorize its being supposed to be the rule, and cause the creation of a distinct thyroid and laryngeal artery; since each branch of the vessel is distributed to the larynx and thyroid body at the same time.

[2] We regard it as the analogue of the *middle thyroid* of Man.

its track, this artery is crossed, outwardly, by the pneumogastric and spinal nerves, and the occipital nerve of the great sympathetic, and is accompanied by the divisions of the inferior branch of the first pair of cervical nerves.

The two terminal branches of the vessel are the *occipito-muscular* and *cerebro-spinal arteries*.

The collateral branches are three in number, and in the order of their emission are named: 1. The *prevertebral artery*. 2. The *mastoid artery*. 3. The *atloido-muscular* (*ramus anastomoticus*, or *retrograde*) *artery*.

COLLATERAL BRANCHES.—1. **Prevertebral Artery** (Fig. 381, 9).—The smallest of all the branches emanating from the occipital, this artery is detached at a very acute angle, and immediately divides into several filaments, some *muscular*, the others *meningeal*. The majority of the first pass between the occipito-atloid articulation and the rectus capitis anticus minor muscle of the head, and expend themselves either in that muscle, or in the rectus capitis anticus major; the second, generally two in number, are always very slender, and reach the dura mater by entering, one through the foramen lacerum basis cranii, the other by the condyloid foramen.

Sometimes the prevertebral artery arises from the common carotid, near the occipital and internal carotid.

2. MASTOID ARTERY (Fig. 381, 8).—This vessel arises at an acute angle above the preceding, and goes towards the mastoid foramen by creeping on the external surface of the styloid process of the occipital bone, beneath the obliquus capitis anticus. It enters the parieto-temporal canal by this foramen, to anastomose by inosculation with the spheno-spinous branch of the internal maxillary artery.

In its course it describes a curve downwards, and throws off a large number of collateral branches. Among these are some which originate before the artery enters its bony canal, and which are destined for the muscles of the nape of the neck. Others arise in the interior of this canal, and escape from it by the orifice in the temporal fossa, to expend themselves in the temporal muscle. Some ramuscules reach the dura mater.

We have seen the mastoid artery arise directly from the common carotid, and furnish a parotideal branch. We have also found it passing over the surface of the obliquus capitis anticus, and curve suddenly to enter the parieto-temporal canal.

3. **Atloido-muscular (Ramus Anastomoticus) or Retrograde Artery** (Fig. 381, 7).—This branch is not constant, and when it does exist it presents a variable volume. It is detached from the occipital, underneath the transverse process of the atlas, by forming with the parent branch a right, or even an obtuse angle; it is directed backwards, traverses the inferior foramen in the transverse process of the atlas, places itself beneath the atlo-axoid muscle, and in a flexuous manner advances to meet the vertebral artery, which it directly joins, after giving off some branches to the great oblique and neighbouring muscle. This anastomosis is the means of establishing a collateral communication between the vertebral artery and the divisions furnished by the common carotid; so that these two arteries can mutually assist or supplant each other.[1]

TERMINAL BRANCHES.—1. **Occipito-muscular Artery** (Fig. 381, 10).—Covered at its origin by the obliquus capitis inferior, the occipito-muscular artery

[1] In a Mule we have found a large anastomosis between the retrograde and mastoid arteries, beneath the ala of the atlas.

is directed transversely inwards to the surface of the rectus capitis posticus major, and soon separates into several branches—ascending and descending; these are mixed with the divisions of the first superior cervical branch, all of which go to the muscles and integuments of the occipital region. The descending branches anastomose with the terminal divisions of the superior cervical artery.

2. **Cerebro-spinal Artery.**—This vessel enters the spinal canal by the anterior foramen of the atlas, traverses the dura mater, and divides into two branches on the inferior face of the spinal cord. Of these two branches, the anterior is united, by convergence, with the analogous branch of the opposite artery on its arrival at the middle of the inferior surface of the medulla oblongata, and so forms the *basilar artery;* the other passes backwards, and constitutes the origin of the *middle spinal artery*, by anastomosing, after a short course, with the corresponding branch of the other cerebro-spinal artery. There results from this distribution a kind of vascular lozenge, situated at the lower face of the medulla oblongata, which receives in its middle the two cerebro-spinal arteries. This regular arrangement is not, however, always observed; these arteries may unite at the posterior extremity of this lozenge, as is shown in Fig. 389.

Basilar Artery.—This is a single vessel that creeps in a somewhat flexuous manner on the inferior face of the medulla oblongata, beneath the visceral arachnoid membrane, and, passing over the pons Varolii, terminates at the anterior border of this portion of the isthmus, by anastomosing with the two posterior cerebral arteries (Fig. 380, 11, 11).

On its course it gives off:

1. A multitude of plexuous ramuscules, which enter the substance of the medulla oblongata and the pons Varolii, or are distributed to the roots of the nerves emanating from the medulla oblongata.

2. The *posterior cerebellar arteries*—vessels liable to numerous anomalies in their origin. They usually arise from the basilar artery at a right angle, behind the posterior border of the pons Varolii, and bend outwards—one to the right, the other to the left—by passing along the surface of the medulla oblongata, the external border of which it thus reaches; they are then inflected backwards beneath the cerebellar plexus choroides, whence they spread their ramifications on the lateral and posterior parts of the cerebellum.

3. The *anterior cerebellar arteries*—two or three on each side, only one of which is constant. These vessels are very variable in their disposition, and arise from the terminal extremity of the basilar artery, in front of the pons Varolii, and sometimes even from the posterior cerebral arteries. Usually united in fasciculi, they are directed outwards and a little backwards in turning round the crura cerebri, and plunge into the anterior part of the cerebellum.

4. Two branches anastomosing with the internal carotid artery. These branches are not constant, and are most frequently met with in the **Ass.** They begin at the basilar artery in front of the posterior border of the pons Varolii, traverse the dura mater to enter the cavernous sinus, and join the carotid arteries at their second curvature.

Middle Spinal Artery.—A very long vessel, lodged in the inferior fissure of the spinal cord, and measuring the whole extent of that organ, which it follows from before to behind. It is from this artery that are given off the branches that cover with their arborizations the medullary tissue, or penetrate its substance. This emission, which ought soon to exhaust the artery, does not, however, sensibly diminish its diameter; as it receives on both sides, during its course, numerous additional vessels. Two series of ramuscules, in fact, emanate either from the vertebral, intercostal, lumbar, or sacral arteries, enter the spinal canal by the intervertebral foramina, and join this artery. Generally, however, they do not pass to the spinal cord until they have anastomosed with each other outside the dura mater, so as to form on the floor of the vertebral canal two lateral vessels placed beside the venous sinuses, and united by transverse anastomoses; this disposition is most evident in the cervical region of the **Ox** (Fig. 382).

Internal Carotid Artery (Figs. 380, 7; 381, 5).

One of the terminal branches of the common carotid, the internal carotid ascends at first to beneath the base of the cranium, outside the anterior straight muscles of the head, and bends forward to reach the foramen lacerum basis cranii. In this primary portion of its course, it is suspended in a particular fold of the guttural pouch, margined by the superior cervical ganglion, accompanied by the cavernous branch of the sympathetic nerve, and crossed in various directions by the nerves that form the guttural plexus. On arriving at the middle of the occipito-spheno-temporal hiatus, it enters the cavernous sinus, and in the interior of that cavity, where it is bathed in venous blood, describes two successive and opposite curvatures—the first, looking forwards, occupies the carotid fossa in the sphenoid bone; the second, with its convexity posterior, at which the internal carotid receives an anastomosing branch from the basilar artery—which branch is voluminous and nearly constant in the **Ass**; but is rare and, when present, very slender in the Horse. After the last inflection, the two internal carotids communicate by a very large transverse branch, which is always flexuous, often reticulated, and leave the cavernous sinus in crossing the dura mater, to gain the cranial cavity.

These arteries are then placed at the sides of the pituitary gland, within the superior maxillary nerve, proceed from behind forward, and terminate in two branches before reaching the optic nerve. One of these branches constitutes the *posterior communicating artery*; the other soon bifurcates to form the *middle* and *anterior cerebral arteries*.

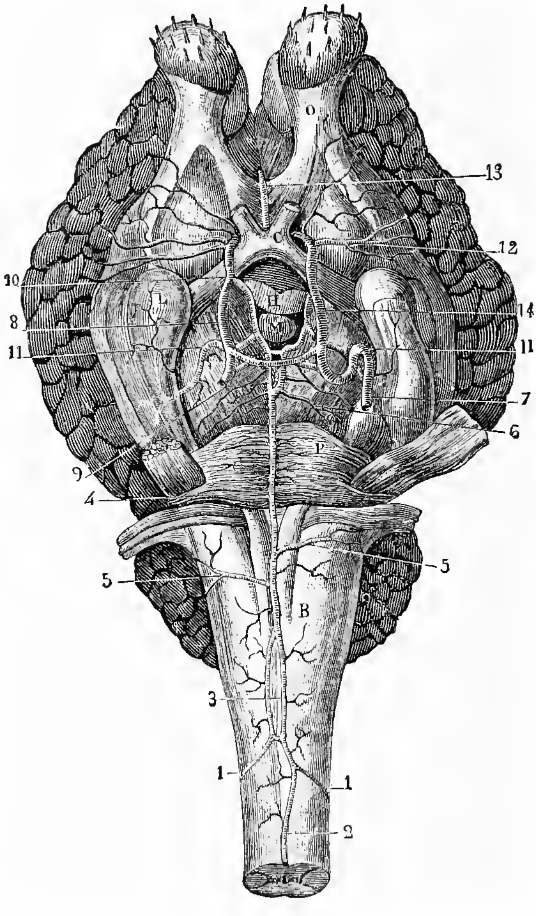
Posterior Cerebral Artery.—This vessel is inflected from before to behind, to one side of the pituitary gland (Fig. 380, 14), and anastomoses behind it, forming on the crura an arch which is often reticulated, and which receives the basilar artery in the middle of its convexity.

A multitude of hair-like ramuscules escape from this artery and enter the substance of the crura; but the principal branches it emits proceed in a flexuous manner inwards and backwards, towards the great cerebral fissure, and terminate either on the posterior extremity of the cerebral hemisphere or in its interior—in the plexus choroides, or even in the cerebellum. The disposition and number of these branches are very variable, but there is one which may be regarded as constant; this is the largest of all, and certainly merits the designation of posterior cerebral artery (Fig. 380, 11).

Middle Cerebral Artery.—This vessel separates itself from the anterior cerebral artery, external to the optic commissure, is lodged in the fissure of Sylvius, passing through it in a flexuous manner, and at its extremity separates into several branches which ramify on the lateral and superior faces of the brain, and anastomose by their terminal divisions with the posterior and anterior cerebral arteries.

Anterior Cerebral Artery.—This enters immediately above the optic commissure, and proceeds inwards to unite, in the middle line, with the opposite artery, forming with it a single vessel. This middle artery (or *arteria corporis*

Fig. 380.



ARTERIES OF THE BRAIN.

B, Medulla oblongata; P, pons Varolii; L, mastoid lobule; O, olfactory lobule; C, chiasma of the optic nerves; M, mammillary or pisiform tubercle (corpus albicans); H, pituitary gland (three-fourths have been excised). 1, 1, Cerebro-spinal arteries; 2, middle spinal artery; 3, lozenge-shaped anastomosis of the two cerebro-spinal arteries, from which result, in front—4, the basilar artery (usually the cerebro-spinal arteries arrive in the middle of the lozenge); 5, 5, posterior cerebellar arteries; 6, anterior ditto; 7, internal carotid artery, with the sigmoid curve it makes in the cavernous sinus; 8, internal carotid on the sides of the pituitary gland; 9, transverse reticulated anastomosis thrown between the two internal carotids behind the pituitary gland; 10, bifurcation of the internal carotid; 11, 11, posterior cerebral arteries anastomosing behind the corpus albicans, receiving in the middle of this anastomosis the two terminal branches of the basilar artery; 12, middle cerebral artery; 13, anterior cerebral artery; 14, posterior communicating artery.

callosi) enters the longitudinal fissure of the brain by bending round the anterior extremity of the corpus callosum, and, after a short course, divides into two branches which pass from before to behind, one to the right, the other to the left, on the internal face of the hemispheres, a short distance from the corpus callosum, and near the posterior extremity of that great commissure. The branches emitted by these arteries—either in their track or at their termination—anastomose with those of the posterior and middle cerebral arteries, as well as with the lobular branch of the ophthalmic.

Before uniting in a common trunk, the two anterior cerebral arteries receive the meningeal branch of the ophthalmic, the calibre of which often even surpasses that of these vessels.

From the anastomosis of the anterior cerebral arteries and the posterior cerebral with the terminal branches of the basilar artery, there results on the inferior surface of the pons Varolii an irregular arterial circle—the *circle* or *polygon of Willis*, which surrounds the pituitary gland. From this circle are detached six groups of arterioles, which are destined to supply the principal grey masses in the brain—the corpus striatum and optic thalami.

External Carotid Artery (Fig. 381, 12).

This artery ought to be considered, because of its volume and direction, as the continuation of the common carotid. It is directed forward, arrives at the posterior border of the great cornu of the os hyoides, passes between it and the stylo-hyoid muscle, and is inflected so as to form an elbow which is turned forward, and afterwards ascends vertically to near the neck of the condyle of the inferior maxilla, at the posterior angle of the hyoid branch. There it bifurcates to give rise to the *superficial temporal* and *internal maxillary arteries*.

In the first part of its course—that is, from its origin to the hyoid bone—the external carotid artery is related: inwardly, to the guttural pouch and the glosso-pharyngeal and superior laryngeal nerves; outwardly, to the outer belly of the digastric muscle, and the hypoglossal nerve.

In its second portion, it is comprised between the guttural pouch, the parotid gland, the great cornu of the os hyoides, and the inner side of the posterior border of the inferior maxilla.

The collateral branches this artery furnishes are three principal—the *glosso-facial*, *maxillo-muscular*, and *posterior auricular*. But it also gives off others of less importance, which are distributed to the guttural pouch, the guttural glands, and the parotid gland.

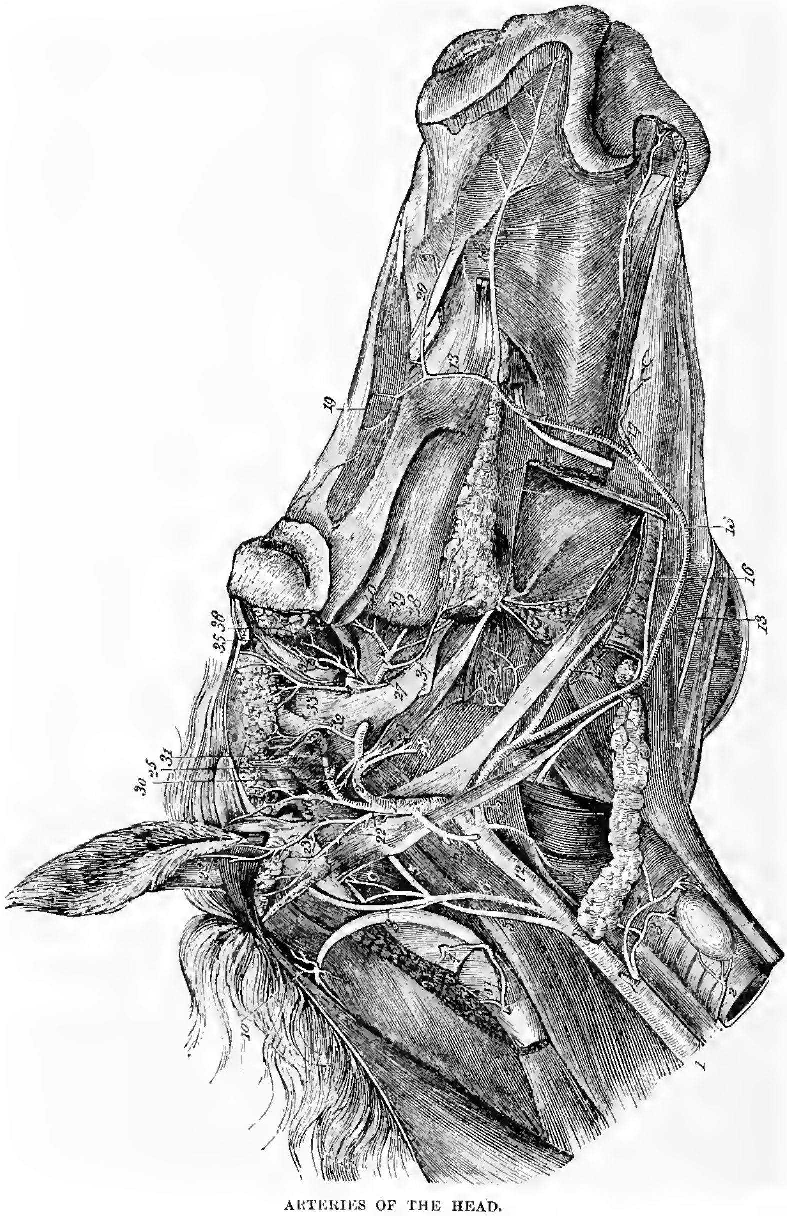
Collateral Branches of the External Carotid.

1. Submaxillary, Facial (or Glosso-facial) Artery (Fig. 381, 13).

This arises from the external carotid, at the point where that vessel passes beneath the stylo-hyoid muscle, and is immediately inflected downwards on the side of the pharynx, between the posterior border of the large cornu of the hyoid bone and the above muscle. It passes in proximity to the anterior extremity of the maxillary gland, crossing Wharton's duct outwardly, and leaves the deep situation it at first occupied, to become more superficial in the submaxillary space, where it rises on the surface of the internal pterygoid muscle, and is directed forwards to the maxillary fissure. Turning round this fissure, it climbs on the cheek, in front of the masseter muscle, to above the maxillary spine, where it terminates in two small branches.

In its long and complicated course, the submaxillary artery describes a semi-circle upwards, and is very naturally divided, for the study of its relations, into

Fig. 381.



ARTERIES OF THE HEAD.

1, Common carotid artery; 2, accessory thyroid artery; 3, 4, thyro-laryngeal artery, divided into two branches; 5, internal carotid artery; 6, occipital artery; 7, atloido-muscular artery at its exit from the inferior foramen of the atlas; 8, mastoid artery; 9, prevertebral artery; 10, occipito-muscular artery; 11, terminal extremity of the vertebral artery joining the atloido-muscular branch; 12, external carotid artery; 13, submaxillary artery; 14, pharyngeal artery; 15, lingual artery; 16, sublingual artery; 17, coronary, or inferior labial artery; 18, three portions—a deep, an intermaxillary, and a facial. The first, or deep portion, accompanied in its superior moiety by the glosso-pharyngeal nerve, is related, outwardly, to the internal pterygoid muscle; inwardly, to the guttural pouch, the hyo-pharyngeus, hypoglossal nerve, middle tendon of the digastricus, the hyo-glossus brevis, Wharton's duct, and the subscapulo-hyoideus. The intermaxillary, or middle portion, is bordered by the glosso-facial vein, lies against the pterygoideus internus, and is in contact with the submaxillary glands. The facial, or terminal part, is lodged at its commencement in the maxillary fissure, in front of the glosso-facial vein and the parotid duct; it ascends with these two vessels along the anterior border of the masseter, on the depressor labii inferioris and buccinator muscles, beneath the subcutaneous and zygomaticus muscles and the ramifications of the facial nerve, which perpendicularly crosses the direction of the artery.

Terminal Branches.—The external maxillary artery terminates in two small branches which separate from each other at an obtuse angle, one being directed upwards, the other downwards. The *ascending* branch passes to the surface of the orbicularis palpebrarum, below the lachrymalis, and anastomoses with the divisions of a palpebral branch emanating from the supermaxillo-dental artery (Fig. 381, 19). The *descending* branch goes to the false nostril and the entrance to the nasal cavities, by creeping beneath the levator labii superioris (Fig. 381, 20).

Collateral Branches.—These are five principal branches: 1. The *pharyngeal*. 2. *Lingual*. 3. *Sublingual*; all of which arise from the first portion of the submaxillary artery. 4. The *inferior* and *superior coronary arteries*, emanating from the facial portion. Besides these, there are a great number of innominate branches of secondary importance, which proceed to the neighbouring parts, and principally to the maxillary gland, submaxillary glands, the masseter muscle, and the muscles and integuments of the face. We will content ourselves with merely noting the existence of these latter branches.

1. **Pharyngeal Artery** (Fig. 381, 14).—This arises from the submaxillary, at a variable distance from its origin, and sometimes even in the angle formed by that vessel and the external carotid artery. Whatever may be its commencement, it is always directed forwards, passes between the hyo-pharyngeus muscle and the great cornu of the hyoid bone, and, describing some flexuosities, goes towards the pterygoid process, beneath the elastic layer which covers the pterygo-pharyngeus muscle. It terminates in the soft palate, after giving off on its course ascending and descending branches, which expend themselves in the walls of the pharynx.

2. **Lingual Artery** (Fig. 381, 15).—As considerable in volume as the parent branch, this artery is detached at an acute angle from it, at the extremity of the hyoid cornu. With the glosso-pharyngeal nerve, it passes beneath the hyo-glossal muscle, crossing the small branch of the os hyoides, and extends to the extremity of the tongue by gliding in the interstice between the genio-glossus

coronary, or superior labial artery; 19, superior terminal branch of the external maxillary artery; 20, inferior terminal branch of ditto; 21, maxillo-muscular artery; 22, 23, posterior auricular artery; 24, superficial temporal artery; 25, subzygomatic artery; 26, inferior auricular artery; 27, internal maxillary artery; 28, inferior dental artery; 29, fasciculi of pterygoid arteries; 30, tympanic artery; 31, spheno-spinous artery; 32, deep posterior temporal artery; 33, deep anterior temporal artery; 34, ophthalmic artery; 35, supra-orbital artery; 36, lachrymal artery; 37, buccal artery; 38, palatine artery; 39, superior dental arter; 40, orbital branch of that vessel and hyo-glossus muscle, where it meets the branches of the lingual and hypoglossal nerves.

Flexuous in its course, in order to adapt itself to the elongation of the tongue, the lingual artery emits a very great number of collateral branches, which escape perpendicularly from the entire periphery of the vessel ; but chiefly above, below, and on the inner side, to ramify in the muscles and integuments of the tongue.

Running parallel to each other, the two lingual arteries communicate by five transverse ramuscules, and join at their terminal extremity, which becomes very slender.

3. **Sublingual Artery** (Fig. 381, 16).—This artery has its origin at the anterior extremity of the submaxillary gland, and runs forward along the external surface of the mylo-hyoideus muscle, which it afterwards crosses towards the posterior extremity of the sublingual gland. It then follows the inferior border of this gland, sending into it numerous branches, and after giving some filaments to the genio-glossus and genio-hyoideus muscles, is prolonged on the sides of the frænum linguæ, where it ends by fine ramuscules in the buccal mucous membrane.

Among the branches this artery detaches before attaining the sublingual gland, it is necessary to distinguish those which are destined to the mylo-hyoideus muscle, some of which—the descending—are thin and irregular ; the others—ascending—being long, thick, and parallel to each other.

Sometimes this artery does not reach the sublingual gland ; it then remains, for the whole of its extent, external to the mylo-hyoideus muscle, and sends its terminal divisions to the vicinity of the symphysis of the inferior maxilla. In this case, the gland receives a special branch from the lingual artery, a circumstance which is usual in Man, in whom this artery is named the *submental.*

4. **Coronary or Inferior Labial** (Fig. 381, 17).—Springing from the glosso-facial artery at an acute angle, shortly before that vessel arrives at the depressor labii inferioris, the inferior coronary artery passes under that muscle, and following its direction, descends into the texture of the lower lip, where it is mixed up with the ramifications of the mental nerve, and where it terminates by forming a very fine anastomotic arch with the vessel of the opposite side.

In its track, it gives branches to the buccinator and depressor labii inferioris muscles, and to the tissues of the lower lip, to which it is chiefly destined. In its passage near the mental foramen, it receives the inferior dental artery as it leaves that opening.

5. **Coronary or Superior Labial Artery** (Fig. 381, 18).—Smaller than the preceding vessel, and often altogether rudimentary, this artery is detached from the principal trunk at nearly a right angle, above the origin of the dilator naris lateralis, and sometimes below that muscle. It subsequently gains the upper lip, along with the infra-orbital branches of the superior maxillary nerve, by passing between the levator labii superioris proprius and the dilator naris lateralis ; it then terminates in forming an arch by inosculation with the palato-labialis artery.

The branches it gives off pass to the external ala of the nose and the textures of the upper lip. Some are expended in the muscles just named, and in the buccinator.

2. Maxillo-muscular Artery (Fig. 381, 21).

The maxillo-muscular artery is a vessel that does not appear to have its representative in Man. It emerges from the external carotid, above the point where it is included between the large cornu of the os hyoides and the stylo-hyoideus muscle. Remarkable for the very obtuse angle it forms at its origin with the principal vessel, it descends behind the posterior border of the inferior maxilla, covered by the parotid gland. It then divides into two branches —a deep one, which goes to the internal pterygoid muscle, after furnishing some ramuscules to the neighbouring organs ; and a superficial one, which turns round the posterior border of the maxilla, and emerging from beneath the parotid gland, above the insertion of the sterno-maxillaris muscle, plunges into the masseter, and expends itself in the body of that muscle by several branches which anastomose with the divisions of the subzygomatic artery.

3. Posterior Auricular Artery (Fig. 381, 22).

Third collateral branch of the external carotid, the posterior auricular artery arises at a very acute angle above, and a little behind, the preceding vessel. It ascends beneath the parotid gland, behind the base of the concha of the ear, crosses the cervico-auricular muscles, and reaches the extremity of the cartilage by passing underneath the skin which covers its posterior plane.

In its course, it emits several ascending auricular branches, which arise at different elevations and cover the concha with their divisions. Among these we ought to distinguish the first (Fig. 381, 23) ; this has its origin at the temporal trunk, and soon divides into two branches—one, profound, after sending a very thin filament into the middle ear by the stylo-mastoid foramen, passes between the external auditory canal and the mastoid process to enter the subconchal adipose tissue and the internal scuto-auricular muscle ; the other, superficial, embedded in the parotid tissue, proceeds to the external side of the concha, and buries itself in the interior of that cartilage, along with the middle auricular nerve, after abandoning some external ramuscules.

From these auricular branches there also escape a multitude of parotideal twigs.

Terminal Branches of the External Carotid.

1. Superficial Temporal Artery or Temporal Trunk (Fig. 381, 25).

This is the smallest of the two terminal branches of the external carotid. After a short ascending course between the parotid gland, the guttural pouch, and the neck of the maxillary condyle, behind which it is situated, this artery is divided into two branches : the *anterior auricular* and the *subzygomatic*.

Anterior Auricular Artery (Fig. 381, 26).—This vessel appears to be, not only by its volume, but also by its direction, the continuation of the temporal artery. Embraced, near its origin, by the facial nerve and subzygomatic branch of the inferior maxillary nerve, it rises behind the temporo-maxillary articulation and supra-condyloid process, beneath the parotid gland, to the temporal muscle, into which it passes after emitting parotideal twigs and auricular branches, one of which penetrates to the interior of the concha, while the others are expended in the anterior muscles of the ear and the integuments covering these muscles.

Subzygomatic Artery (Fig. 381, 25).—More considerable than the anterior auricular, this artery disengages itself from beneath the parotid gland by turning round the posterior border of the maxilla, along with the nervous anastomosis which gives rise to the subzygomatic plexus, and is placed above that anastomosis, beneath and to the outside of the afore-mentioned condyle. There it ends in two branches of equal volume—a superior or superficial, and an inferior or deep, both of which ramify in the substance of the masseter muscle, and anastomose with the divisions of the maxillo-muscular, or with the masseter branches of the external maxillary arteries.

The *superior branch*, or *transverse artery of the face*, goes towards the anterior border of the masseter muscle in a flexuous manner, close to the zygomatic ridge. At first lying on the superficies of the masseter, it afterwards buries itself in that muscle.

The *inferior branch*, or *masseteric artery*, dips in among the deep fasciculi of the masseter muscle, to which it is distributed, along with the masseteric nerve. Near its origin, it communicates with the deep posterior temporal artery by a fine ramuscule, which passes into the sigmoid notch. In Man and some animals, this artery comes from the internal maxillary.

2. Internal Maxillary or Gutturo-maxillary Artery (Fig. 381, 27).

Situated at first immediately within the maxillary condyle, below the articulation of the jaw, this artery passes to the inner side, towards the entrance of the subsphenoidal canal, by describing two successive curvatures—the first backwards, the other forwards. After being thus shaped like an S, it travels forward along the subsphenoidal canal to the orbital hiatus, and then reaches the maxillary hiatus, where it is designated the *palato-labial artery*.

In order to study its relations, the course of this artery may be divided into three portions—a posterior or guttural, a middle or sphenoidal, and an anterior or infra-orbital. The posterior portion lies on the internal face of the external pterygoid muscle, covered inwardly by the guttural pouch, and crossed outwardly by the inferior maxillary nerve and some of its branches. The middle division is enveloped by the bony walls of the subsphenoidal canal. The anterior portion, along with the superior maxillary nerve, passes across the space separating the orbital from the maxillary hiatus, by creeping along the palatine bone, beneath a considerable mass of fat.

Collateral Branches.—The arteries given off by the internal maxillary on its course are eleven principal. Five arise from the first portion of the vessel: two below, the *inferior dental* and the group of the pterygoid arteries; three above, the *tympanic*, *spheno-spinous* (*great meningeal*), and *posterior deep temporal*.

Two escape from the superior portion of the interosseous or sphenoidal division. These are the *anterior deep temporal* and *ophthalmic arteries*. Four commence from the third section of the artery: two inferior, the *buccal* and *palatine*; and two upper, the *superior dental* and the *nasal*.

1. **Inferior Dental Artery** (Fig. 381, 28).—This vessel—also named the *maxillo-dental artery*—is detached at a right angle from about the middle of the first curvature described by the internal maxillary. It travels forward and downward between the two pterygoid muscles, afterwards between the internal one and the maxillary bone, entering with the inferior maxillary nerve into the dental foramen, through the whole extent of which it passes. Arrived at the mental foramen, it separates into two branches—a deep one, which continues the interosseous course of the vessel, to be distributed to the roots of the tusk or tush, and the three adjoining incisor teeth; the other superficial, generally very slender and even capillary, issuing by the mental foramen with the terminal

branches of the maxillary nerve, and anastomosing with the inferior coronary artery.

Before penetrating the maxilla, this artery furnishes divisions to the internal pterygoid and mylo-hyoid muscles.

In the interior of the maxillo-dental canal, it gives off diploïc branches, as well as twigs, to the roots of the molar teeth and the alveolar membrane.

2. **Pterygoid Arteries** (Fig. 381, 29).—It may be said, in a general manner, that the two pterygoid muscles receive their arteries from all the vessels passing near them ; though there are two, and sometimes three, branches more especially intended for them. These branches—or, properly speaking, *pterygoid arteries*—arise from the middle of the second curvature of the internal maxillary, either at an acute or right angle, and enter the pterygoid muscles, after a short course forward and downward on the external tensor palati muscle—this, and its fellow, the internal muscle, also receiving some branches.

3. **Tympanic Artery** (Fig. 381, 30).—A very thin and small, but constant artery, gliding along the surface of the guttural pouch, accompanying the tympano-lingual nerve, and penetrating the tympanic cavity by a foramen situated at the base of the styloid process of the temporal bone (the *fissura Glaseri*). It throws off ramuscules to the wall of the guttural pouch and the trigeminal nerve ; these often arise directly from the trunk of the internal maxillary artery, beside the tympanic branch.

4. **Spheno-spinous or Great Meningeal Artery** (Fig. 381, 31).—Commencing at an obtuse angle, opposite the pterygoideal vessels, this artery lies against the sphenoid bone, near the temporal insertion of the tensor palati muscles, is directed backwards and upwards, enters the cranium by the foramen lacerum basis cranii, outside the inferior maxillary nerve, passes beneath the dura mater, and soon after engages itself in a particular foramen in the parieto-temporal canal, where it anastomoses by inosculation with the mastoid artery.

Before penetrating this canal, the spheno-spinous artery gives off a meningeal branch, the ramifications of which, destined to the dura mater, stand in relief on that membrane, and creep along in the small grooves channeled on the inner surface of the cranium.

The volume of this vessel is subject to the greatest variations, and is always in an inverse proportion to that of the mastoid artery.

5. **Posterior Deep Temporal Artery** (Fig. 381, 32).—This arises at a right angle, immediately before the entrance of the internal maxillary artery into the subsphenoidal canal. It ascends on the temporal bone, in the temporal muscle, passing in front of the temporo-maxillary articulation, which it turns round to be inflected backwards. This vessel communicates with the masseteric artery by a fine division, which traverses the sigmoid notch in the maxillary bone.

6. **Anterior Deep Temporal Artery** (Fig. 381, 33).—Springing at a right angle, like the preceding, in the interior of the subsphenoidal canal, this artery escapes by the superior branch of that conduit, ascends against the bony wall of the temporal fossa, along the anterior border of the temporal muscle, in which it is almost entirely expended. It gives some ramuscules to the adipose tissue of the temporal fossa. Its terminal extremity arrives beneath the internal parieto-auricularis muscle, and ramifies in it and in the skin of the forehead.

7. **Ophthalmic Artery** (Fig. 381, 34).—This vessel has a somewhat singular arrangement. After being detached from the internal maxillary in the

subsphenoidal canal, in front of the deep anterior temporal artery, with which it is sometimes united, it penetrates by the orbital hiatus to the bottom of the ocular sheath; it then enters the cranium by the orbital foramen, after describing a loop opening backwards and downwards, which passes between the muscles of the eye, beneath the superior rectus, and above the optic nerve and the sheath formed around it by the retractor.

Entering the cranium, the ophthalmic artery passes inward along a groove in the ethmoidal fossa, and terminates by two branches—a *meningeal* and a *nasal*.

Collateral branches.—In its orbital track, the ophthalmic artery emits numerous collateral branches, which arise from the convex side of the loop described by this vessel. These are: the *muscular arteries of the eye*, the *ciliary*, *central artery of the retina*, *supra-orbital*, and *lachrymal arteries.*

In its cranial portion, it furnishes the *cerebral branches.*

The *muscular arteries of the eye* have a destination sufficiently indicated by their name. Their number and mode of origin vary. They are usually two principal, which arise directly from the ophthalmic artery, and others of a smaller size furnished by the lachrymal and supra-orbital branches.

The *ciliary arteries*—destined to the constituent parts of the globe of the eye, but chiefly to the choroid coat, the ciliary processes, and the iris—are long thin branches, emanating, for the most part, from the muscular arteries.

We only mention the *centralis retinæ artery* here; as it and the ciliary arteries will be described when we come to study the visual apparatus.

The *supra-orbital artery* ascends, with the nerve of the same name, against the inner wall of the ocular sheath, to gain the supra-orbital foramen; passing through that orifice, it is distributed to the frontal and supra-orbital muscles, the orbicularis palpebrarum, external temporo-auricularis muscle, as well as to the integument of the frontal region (Fig. 381, 35).

The *lachrymal artery* creeps upwards and forwards, between the muscles of the globe of the eye and the superior wall of the ocular sheath, to terminate in the lachrymal gland and the upper eyelid (Fig. 381, 36).

The *cerebral branches* of the ophthalmic artery vary in number, and frequently there is only one, of somewhat considerable volume. They pass to the anterior extremity of the cerebral lobe, and anastomose with the divisions of the anterior cerebral artery.

Terminal branches.—The *meningeal branch*, after detaching ramuscules to the dura mater, and particularly to the falx cerebri, anastomoses in the middle line, below the process of the crista galli, with that of the opposite side, and afterwards joins the anterior cerebral artery.

The *nasal branch* traverses the cribriform plate of the ethmoid bone, and divides into a number of ramuscules, which descend either on the ethmoidal cells, or on the middle septum of the nose, where their ramifications form arterial tufts of a pleasing aspect.

8. **Buccal Artery** (Fig. 381, 37).—The buccal artery emerges at an acute angle from the internal maxillary, a short distance in front of the orbital hiatus, and descends obliquely between the maxillary bone and the superior insertion of the internal pterygoid muscle, terminating in the posterior part of the molar glands, and in the buccinator and depressor labii inferioris muscles.

In its course it gives some insignificant ramuscules to the pterygoid muscles, as well as to the masseter, and a long branch to the adipose cushion in the temporal fossa. The latter branch sometimes comes directly from the internal maxillary artery.

9. **Staphyline Artery** (Fig. 381, 38).—A very thin filament, which accompanies the staphyline nerve in the groove of the same name, and is distributed to the soft palate.

10. **Superior Dental Artery** (Fig. 381, 39).—This vessel—which is also named the *supermaxillo-dental* artery—enters the superior dental canal, arrives near its inferior or infra-orbital opening, and then divides into two thin branches. One of these continues in the same course in the supermaxillary bone, to supply arterial blood to the alveoli of the foremost molars, the tusk, and the incisor teeth; the other (*infra-orbital branch*) passes out of the canal with the terminal divisions of the superior maxillary nerve, and communicates on the forehead with a ramuscule from the external maxillary artery.

On its way, the superior dental artery emits several collateral branches, the majority of which commence in the interior of the dental canal, and pass either to the alveoli of the posterior molars, the tissue of the bone, or the membrane lining the sinuses. One of these branches—the *orbital*, and the largest—escapes from the principal artery before its entrance to the superior dental canal, creeps along the floor of the orbit towards the nasal angle of the eye, whence it descends on the forehead, after giving off some divisions to the caruncle of the eye, the lachrymal sac, and the lower eyelid.

11. **Nasal or Spheno-palatine Artery.**—Situated, at first, at the bottom of the maxillary hiatus, this artery, springing at a right angle from the parent trunk, traverses the spheno-palatine foramen, and divides into two terminal branches—an external and an internal—in ramifying on the walls of the nasal cavity.

Terminal Branch of the Internal Maxillary Artery. **Palato-Labial or Palatine Artery** (Fig. 215, 3).—A continuation of the internal maxillary, this vessel at first traverses the palatine foramen, follows the palatine groove to near the superior incisors, is then inflected inwards above a small cartilaginous process (Fig. 215, 4), and unites on the middle line with the artery of the opposite side, forming an arch with its convexity forwards, from which proceeds a single trunk that passes into the incisive foramen.

The palatine arteries, in their advance, furnish a series of branches to the anterior part of the soft palate, the membranes on the roof of the mouth, and the gums and upper teeth.

The single trunk resulting from their anastomoses is placed, immediately after its exit from the incisive foramen, directly beneath the buccal mucous membrane, and at once divides into two principal branches—a right and left; these are lodged in the tissue of the upper lip, and pass back to meet the coronary arteries, with which they anastomose by inosculation, after throwing off on their track a great number of branches to the muscles and integuments of the lip and nostrils.

Differential Characters in the Carotid Arteries of the other Animals.

1. The Carotid Arteries in Carnivora.

In the **Dog,** the carotids arise singly from the axillary artery, and ascend beneath the transverse process of the atlas, along the trachea, following a course exactly like that pursued by these vessels in the Horse.

Among the collateral branches furnished by them, may be distinguished the *thyro-laryngeal* *artery*, remarkable for its enormous calibre, its descending in front of the lateral lobes of the thyroid gland, and its termination in the median isthmus of that gland.

The terminal branches of the carotid are, as in Solipeds: 1. The *occipital.* 2. The *internal carotid.* 3. The *external carotid*, the continuation of the common carotid.

Occipital Artery.—Inconsiderable in volume, this vessel arises in front of the anterior border of the transverse process of the atlas, passes into the notch on its border, and divides into two branches—the *occipito-muscular* and the *cerebro-spinal arteries.*

In its course, it gives off branches analogous to those which emanate from the *prevertebral* artery of the Horse. It also gives a *mastoid artery*, which only sends one very small branch into the parieto-temporal canal, and is destined almost exclusively to the deep muscles of the neck. In addition, the occipital throws off a *retrograde artery*, which directly joins the vertebral.

The arrangement of the occipital artery in Carnivora is, therefore, almost identical with what has been described in Solipeds.

Internal Carotid Artery.—This vessel reaches the posterior opening of the carotid canal, along which it passes forward, then describes a very curious flexure which leaves the cranium by the carotid foramen (see p. 59), then re-enters that cavity after receiving a particular branch from the external carotid. It afterwards anastomoses on the side of the pituitary fossa, with the divisions of the spheno-spinous artery and the returning branches of the ophthalmic artery, forming a kind of plexus which appears to be a trace of the *rete mirabile* of Ruminants and Pachyderms, and from which proceed the cerebral arteries.

External Carotid Artery.—This arterial branch terminates, as in Solipeds, by the *superficial temporal* and the *internal maxillary arteries.*

It gives off on its course: 1. An artery representiog the meningeal branch of the *prevertebral* of the Horse, and which ascends in a flexuous manner on the side of the pharynx to join the carotid flexure.

2. A *laryngeal artery*, entering the larynx with the superior nerve of that organ, after giving ramuscules to the maxillary gland.

3. The *lingual artery*, a very large tortuous branch, the course of which resembles that of the same vessel in the Horse.

4. A *facial* or *external maxillary artery*, divided into two branches above the inferior insertion of the digastricus. One of these branches—analogous perhaps to the *submental* of Man—passes within this insertion, and is prolonged to the chin, after furnishing ramuscules to the parts lodged in the intermaxillary space. The other branch winds round the inferior border of the maxilla, in front of the masseter muscle, and is expended on the face by ascending and descending branches, among which we can readily perceive the two *coronary arteries*, and the two twigs which we have noticed in Solipeds as terminal branches of the vessel.

5. The *posterior auricular artery*, after detaching parotideal and musculo-cutaneous vessels, is situated on the middle of the external face of the concha, and is directed towards the terminal extremity of the cartilage, where it separates into two branches, which are inflected *en arcade*, and return, in following the borders of the concha, towards the base of the latter, where they anastomose with other branches, either from the posterior or anterior auricular, and which come to meet them.

Superficial temporal artery.—After a brief course behind the temporo-maxillary articulation, this vessel bifurcates: its posterior or *auricular* branch anastomosing with a division of the posterior auricular, but not before it has sent ramuscules to the interior of the concha, and furnished some musculo-cutaneous twigs. The other, the anterior or *temporal* branch, glides beneath the aponeurosis of the temporal muscle, above the upper margin of the zygomatic arch, and winds upwards and inwards around the outline of the orbit, to terminate on the face by anastomosing ramuscules, either with the infra-orbital branch of the superior dental artery, or with the facial. In its sub-aponeurotic course, it gives divisions to the temporal muscle. Above the orbital arch, it emits several superficial ascending and internal twigs, one of the principal of which communicates by ramuscules with the posterior auricular artery, the auricular branch of the superficial temporal, and with the homologous ramuscules from the opposite side.

Internal maxillary artery.—The course pursued by this vessel is similar to that which it follows in the Horse. After describing an S curvature between the condyle of the maxillary bone and external pterygoid muscle, it traverses the subsphenoidal canal. and passes outside the internal pterygoid towards the maxillary hiatus, where it is continued by the *superior dental artery.*

a. The following are the principal collateral branches emitted by this vessel:

1. The *inferior dental artery.*

2. The *deep posterior temporal artery*, which furnishes a *masseteric branch* that traverses the sigmoid notch in the maxillary bone, to enter the masseter muscle.

3. A fine *tympanic arteriole.*

4. The *spheno-spinous artery,* almost entirely destined to the formation of the plexus of the cerebral arteries.

5. Several *pterygoid arteries.*

6. The *ophthalmic artery,* which, before entering the ethmoidal fossa by the orbital foramen, gives, independently of the branches noted in Solipeds—except the *supra-orbital,* which is absent—a fasciculus of particular branches. These penetrate the cranium by the great sphenoidal fissure, accompanying the motor and sensory nerves of the eye, to join the internal carotid and spheno-spinous arteries.

7. The *anterior deep temporal artery.*

8. A *staphyline artery,* more voluminous than that in the Horse.

9. The *palatine artery.*

10. A *buccal* and an *alveolar artery,* the principal divisions of which enter Duvernoy's gland.

b. The *superior dental artery,* which terminates the internal maxillary, and furnishes an *orbital* and an *infra-orbital branch,* as in Solipeds. The latter, remarkable for its volume, emerges from the superior dental canal with the infra-orbital nerves, to join the divisions of the external maxillary artery on the face, and in the tissue of the upper lip.

2. Carotid Arteries in the Pig.

There is nothing particular to notice regarding the course of these vessels, which we know arise separately from the axillary artery.

Occipital Artery.—In its distribution, it greatly resembles the same vessels in the Horse and Dog. Its most important branches are the following: 1. A very small *retrograde artery,* anastomosing with the vertebral. 2. A branch which ascends into the muscles of the neck, representing the *mastoid artery.* 3. Several occipital arterioles, which pass, with the principal artery, by the anterior foramen of the atlas. This artery is expended in a complete manner in the muscles of the neck, and without sending a cerebro-spinal branch to the interior of the spinal canal.

Internal Carotid Artery.—After furnishing a large meningeal artery, this vessel enters the cranium by the foramen lacerum basis cranii, and there divides to form a *rete mirabile,* analogous to that of Ruminants, and of which a description will be given hereafter. The cerebral arteries arising from this *réseau* differ but little from those of Solipeds; these are the posterior cerebral arteries, which give rise to the basilar artery and originate the middle spinal artery.

External Carotid Artery.—This artery is seen to pass between the pterygoid muscles and the branch of the maxilla, in describing several inflections, and arrives in the maxillary hiatus, without exhibiting in its course any sensible distinction between the external carotid, properly called, and its continuation, the internal maxillary artery.

Among the branches it supplies, we notice:

1. The *lingual artery,* more voluminous, perhaps, than in the other animals.

2. A branch analogous, in its origin at least, to the glosso-facial artery of the Horse, and which distributes its ramuscules in the submaxillary space, and particularly to the salivary and lymphatic glands.

3. The *posterior auricular artery,* noticeable for its great length and considerable volume.

4. The *transverse artery of the face* and the *anterior auricular artery,* arising separately beside each other, and extremely slender.

5. Several *deep temporal* and *masseteric arteries.*

6. *Pterygoid branches.*

7. An enormous *buccal branch.*

8. The *ophthalmic artery,* concurring to form the *rete mirabile.*

9. A small *orbital branch,* coming from the superior dental artery in Solipeds and Carnivora.

10. The *nasal, palatine,* and *superior dental arteries.*

3. Carotid Arteries of Ruminants.

A. In the **Sheep,** which will serve as a type for this description, the carotid arteries arise by a common trunk from the right axillary artery, as in Solipeds. Arriving in the cephalic region, towards the upper part of the neck, they furnish a *thyroid* and a *laryngeal branch,* then give off a very slender *occipital artery,* and are continued from this point by the *external carotid.*

The *internal carotid,* properly called, is absent, and we shall see immediately how it is compensated for.

Occipital Artery.—Having given some ramuscules to the anterior straight muscles of the head, and a small meningeal branch which enters the cranium by the foramen lacerum basis cranii, this vessel passes into the condyloid foramen, which also affords a passage to the hypoglossal nerve, places itself beneath the dura mater, and is inflected backward to open into the anterior extremity of the collateral artery of the spine, at the superior foramen of the atlas. The branch resulting from this junction emerges by that foramen, to be distributed in the muscles of the neck, where its divisions resemble those of the occipito-muscular and atloido-muscular branches in the Horse.

In traversing the condyloid foramen, the occipital artery sends into the parieto-temporal canal, by a peculiar bony conduit (see p. 50), a very small filament which is distributed to the dura mater, in anastomosing with a branch of the posterior auricular.

It communicates, after its entrance into the cranial cavity, with the *rete mirabile.*

External Carotid Artery.—Terminated, as in the Horse, by the *superficial temporal* and *internat maxillary arteries*, this vessel sends off on its course :

1. A *pharyngeal artery*, the origin of which is nearly confounded with that of the occipital artery.

2. The *lingual artery*, furnishing a collateral branch which exactly represents the *sub-*

Fig. 382.

THE RETE MIRABILE OF THE SHEEP, SEEN IN PROFILE.

1, Carotid artery; 2, occipital artery; 3, lingual artery; 4, maxillo-muscular artery; 5, posterior auricular artery; 6, superficial temporal artery; 7, anterior auricular artery; 8, middle temporal artery; 9, transverse artery of the face; 10, internal maxillary artery; 11, inferior dental artery; 12, spheno-spinous artery; 13, deep posterior temporal artery; 14, deep anterior temporal artery; 15, commencement of the originating arteries of the *rete mirabile;* 16, encephalic *rete mirabile;* 17, trunk of the encephalic arteries arising from the *rete mirabile;* 18, ophthalmic artery; 19, ophthalmic *rete mirabile;* 20, common origin of the arteries of the eye; 21, supra-orbital artery; 22, buccal artery; 23, superior dental artery; 24, orbital branch of the latter; 25, palatine artery; 26, nasal artery.

mental of Man, and is divided into two branches that resemble the *sublingual* and *ranine* arteries.

3. A large division for the maxillary gland.

4. The *posterior auricular artery*, from which proceeds: 1. The *stylo-mastoid* arteriole, which penetrates the aqueduct of Fallopius. 2. *Concho-muscular* branches. 3. A large branch, resembling the *mastoid artery* of the Horse. This enters the temporo-parietal canal by a small foramen between the occipital and petrous portion of the temporal bone, and forms two branches : an external, emerging from this canal by the wide orifice in the temporal fossa, and expending itself in the temporal muscle, after anastomosing with the two deep temporal arteries; and an internal—a considerable meningeal artery—destined principally to the falx cerebri and the tentorium cerebelli.

5. A small *maxillo-muscular* artery, ramifying entirely in the internal pterygoid and the subcutaneous muscles.

Superficial temporal artery.—This vessel divides, almost at its origin, into three branches:

1. A posterior, supplying the *anterior arteries* of the ear.

2. An anterior, forming the transverse facial, and terminating by the *coronary* or *labial arteries*, after giving some ramuscules to the masseter and the muscles of the forehead.

3. A median artery, representing the *middle temporal* of Man. This vessel detaches some divisions to the temporal muscle, gives off the *lachrymal artery*, as well as a *palpebral branch* rising from the same point, and terminates near the base of the cranium by two particular arteries that are developed around the base of the horn, and form a real arterial circle from which inferior and superior divisions are given off. The latter are the most considerable, and glide on the bony core of the frontal appendage, where they are distributed almost exclusively to the generating membrane of the horny tissue, only throwing some filaments into the sinuses.

Internal maxillary artery.—It does not traverse the subsphenoidal canal, as that bony passage does not exist.

The following are its principal branches:—

1. The *inferior dental artery*, which emits some pterygoid ramuscules.

2. The *spheno-spinous artery*, arising from the same point as the preceding, often in common with it, giving also some *pterygoid branches*, and entering the cranium by the oval foramen to aid in the formation of the *rete mirabile*, in a way to be indicated hereafter.

3. The *posterior deep temporal artery*, which detaches a *masseteric* artery.

4. The *interior deep temporal artery.*

5. The *buccal*, principally sent to the masseter muscle.

6. The *ophthalmic artery*, longer than in the other animals, forming a loop before traversing the orbital foramen, and giving a *supra-orbital branch* and a fasciculus of *muscular and ciliary arteries*. Near the point where the originating trunk of this fasiculus is detached, the ophthalmic artery shows on its course a very curious arrangement which has not yet been noticed; we believe this is a veritable arterial plexus, in a ganglionic form, in principle exactly disposed as that about to be described (Fig. 382, 19).

7. The *originating arteries of the rete mirabile*, usually consisting of two principal vessels, arising with the ophthalmic, passing backward through the supra-sphenoidal canal, and ramifying in a special manner to form a mass of reticular twigs, designated the *rete mirabile* (Fig. 382, 16).

This network is a small ovoid mass, elongated from before to behind, placed beneath the dura mater, on the side of the sella Turcica, within the superior maxillary nerve, and composed of a multitude of fine arterial divisions which anastomose with each other in an extremely complicated manner. Its inferior extremity, passing into the supra-sphenoidal canal, receives the generating arteries. The posterior extremity, covered by the clinoid process, is in communication with the spheno-spinous artery, which there expends itself. Towards its middle part, and above, the twigs forming it reconstitute themselves into a single trunk analogous to the intercranial portion of the *internal carotid* of Solipeds (Fig. 382, 17), and which traverses the dura mater, dividing into three branches. These are the *anterior*, *middle*, and *posterior cerebral arteries*; the latter anastomoses, by convergence, with the homologous artery of the opposite side, behind the pituitary gland, to form the basilar artery and the middle spinal artery, which continues it.

This singular disposition of the arteries of the encephalon well deserves the name of *rete mirabile* (wonderful network), by which it is known. If we were desirous of giving a summary idea of this network, we might compare it to a lymphatic gland, the efferent vessels of which would be represented by the *originating arteries* with the *spheno-spinous*, and the efferents by the originating trunk of the encephalic arteries.

8. Next comes the *superior dental*, the *orbital branch* of which presents a considerable volume, and terminates on the anterior surface of the head by long superficial divisions. Some of these—the ascending—anastomose with the inferior branches of the arterial circle situated around the base of the horn; while others, the descending, communicate with the *infra-orbital branch* of the same vessel, and with the superior coronary artery.

9. The last to be given off are the *nasal* and *palatine arteries*, which terminate the internal maxillary: the *nasal artery* is disposed as in the Horse; the *palatine* goes entirely to the palate.

B. In the **Ox**, we find all the peculiarities just enumerated, except with the following differences:—

1. A little above the origin of the lingual artery, the external carotid gives rise to an

external maxillary artery, which turns round the inferior border of the maxilla, in company with its satellite vein, and terminates on the forehead, as in the Horse, after supplying the coronary arteries.

2. The *maxillo-muscular artery* is distributed to the two masseters—to the external, as well as the internal.

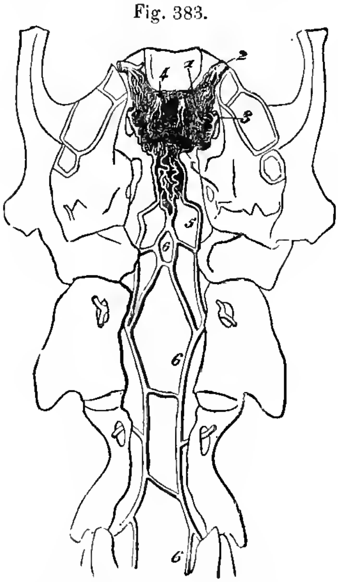
3. The *transverse artery of the face* does not form the coronary arteries, as these come from the external maxillary; it is altogether expended in the masseter muscle.

4. The *anterior auricular artery* sends an enormous branch into the temporo-parietal canal, by the orifice situated behind the supra-condyloid process.

5. The *ophthalmic artery* and the *generating arteries* of the *rete mirabile* proceed from a common trunk.

6. The *rete* itself shows some differences. We do not find, as in the Sheep, two lateral elongated lobes, almost independent of each other, but a circular mass surrounding the sella Turcica. Besides, the occipital arteries concur in its formation, and pass into its posterior part (Fig. 383).

Fig. 383.



THE RETE MIRABILE OF THE OX (POSTERIOR FACE).

1, *Rete mirabile;* 2, trunk of the originating arteries of the *rete mirabile;* 3, spheno-spinous artery; 4, trunk of the encephalic, or internal carotid arteries; 5, branches of the occipital passing to the *rete mirabile;* 6, interspinal arterial canal, formed by the intervertebral spinal branches.

(This *rete mirabile* of Galen would appear to be formed on the carotid and vertebral arteries of animals, which, in a state of nature, feed from the ground; the object being to furnish an equable and prolonged supply of blood without the risk of check or hindrance, and thus to obviate the tendency to congestion of the brain during the dependent position of the head. This minute subdivision and subsequent reconstitution of an artery, with a like intention, is also observed in other creatures besides grazing animals. The vessels in the arm of the sloth are so disposed that the animal can remain suspended by it for long periods; and a similar arrangement is noted in the legs of birds—such as the Swan, Goose, etc., which stand for a long time. Around the Horse's foot the arteries break up into numerous divisions, and we know that this animal can remain in a standing attitude for months, and even years. The *rete ophthalmicum* of birds is arranged like the *rete mirabile.* The same object is sometimes attained by great tortuosity, as we have already seen in the description of several of the arteries. Perhaps the most marked example, however, is to be found in the carotid artery of the Seal, which is nearly forty times longer than the space it has to traverse.

But it may be remarked that there is no *rete mirabile* in the Horse—though it is also a grazing animal—at all to be compared with that of Ruminants, the circle of Willis being its only representative.)

Comparison of the Carotid Arteries of Man with those of Animals.

The *common carotids* of Man have a different origin, the right arising from the arteria innominata, the left from the arch of the aorta. At the inferior border of the thyroid cartilage, they terminate by only two branches—the external and internal carotids; the occipital artery is but a division of the former.

Internal Carotid Artery.—Contrary to what is observed in animals, the internal carotid is a little larger than the external, a difference which is explained in Man by the predominance of the cranium over the face. This vessel describes a flexuous course until it reaches the carotid foramen in the petrous bone; it forms two curves in the cavernous sinus, penetrates the dura mater, and divides at the fissure of Sylvius into four branches, which are, as in Solipeds: the *posterior communicating, anterior cerebral, middle cerebral,* and *artery of the choroid plexus.* The internal carotid has an important collateral branch—the *ophthalmic artery*—that arises from the convexity of the curve the carotid makes inside the anterior clinoid process, at the bottom of the orbit. If it differs at its origin, yet this vessel has a distribution analogous to that already described.

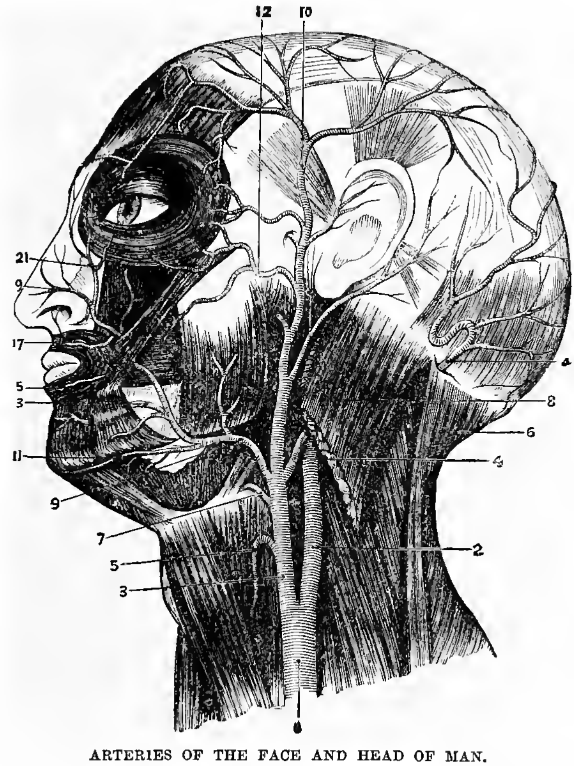
External Carotid Artery.—In its origin, course, and termi ation, the external carotid comports itself as in animals. It gives rise to six branches:

1. The *superior thyroid*, resembling in its distribution the thyro-laryngeal of Solipeds.
2. The *lingual artery*, which furnishes a sublingual, and takes the name of *ranine* at its termination.
3. The *facial artery*, which gives off the palatina ascendens, analogous to our pharyngeal, and the submental.

The two last-mentioned arteries arise separately; consequently, there is not a glosso-facial in Man as we have seen it in the Horse.

4. The *posterior auricular artery.*
5. The *inferior pharyngeal artery.*
6. The *occipital.*—This vessel represents the occipital of the Horse *minus* its cerebro-spinal

Fig. 384.



ARTERIES OF THE FACE AND HEAD OF MAN.

1, Common carotid; 2, internal carotid; 3, external carotid; 4, 4, occipital artery· 5 superior thyroid artery; 6, trapezius; 7, lingual artery; 8, sterno-mastoid; 9, facial artery; 10, temporal artery, dividing into anterior and posterior branches; 11, submental branch; 12, transverse facial artery; 13, inferior labial branch; 15, inferior coronary, and, 17, superior coronary branch; 19, lateral nasal branch; 21, angular branch.

branch. It gives off a mastoid artery, and terminates in the muscles of the neck and on the posterior aspect of the cranium. The cerebro-spinal branch is replaced by the termination of the vertebral artery, which forms on the inferior face of the medulla oblongata the *basilar* artery, the disposition of which is identical with that already described.

The *superficial temporal artery*, and the *internal maxillary artery*, constitute the termination of the external carotid.

The *internal maxillary* is directed towards the spheno-palatine or nasal foramen, into which it passes and terminates by the spheno-spinous artery. It does not give off the ophthalmic artery, that vessel coming from the internal carotid; but it furnishes all the other branches we have studied in animals. There are, therefore: a *tympanic artery;* a *meningeal, middle,* or *spheno-spinous;* an *anterior* and *posterior deep temporal;* an *inferior dental;* a *buccal;* a *masseteric; pterygoideans;* and a *descending palatine* or *palato-labial* artery.

THIRD SECTION.

THE VEINS.

CHAPTER I.

GENERAL CONSIDERATIONS.

Definition.—The *veins* are the centripetal vessels of the circulatory system. They bring back to the heart the blood which has been carried from that viscus to the organs.

Division.—Some proceed from the lungs, carrying red blood, and converge towards the left auricle of the heart: these are the *pulmonary veins,* or *veins of the lesser circulation.* Others emerge from the mass of all the organs, transport the dark blood, and open into the right auricle: these are the *veins of the general circulation.*

There are, therefore, two venous systems commencing by a capillary network, opposite an arterial network. Sometimes a third system of veins has been described for the intestines; indeed, the vena portæ offers a certain independence in the midst of the veins of the general circulation, as it terminates in a capillary plexus in the interior of the liver, and by this plexus it communicates with the posterior vena cava.

General Disposition.—The veins, after succeeding the capillary networks which terminate the arteries, or the spaces in the erectile tissues, form a series of convergent ramifications which repeat, in a general manner—but in an inverse sense—the arterial ramifications, the course of which they for the most part follow. A certain number, nevertheless, are placed at some distance from the arterial trunks, beneath the external tegumentary membrane, where they are disposed in a vast network that constitutes the *superficial veins* of the body. Apart from this peculiarity, we have nothing more to say with regard to the *situation, direction, relations,* and *anastomoses* of the veins than has been already made known in studying the arteries. It is only to be remarked, that the anastomoses of the venous system are more numerous, larger, and more complex than those of the arterial system; that they also communicate with more voluminous trunks; and that they very often join the deep to the superficial veins. At certain points—external genital organs, bladder, rectum—the anastomoses are so numerous as to constitute veritable *venous plexuses.* These are more especially met with in regions where the circulation is liable to be more or less hindered, either from the displacement of organs or variations in their volume. Fenwick has made known some important communications with regard to the maintenance of the circulation; for instance, those between the subcutaneous veins, the large veins of the limbs, and the substance of the thoraco-abdominal parieties; and between the vena portæ and the deep epigastric and vesical veins.

Form.—With regard to *form*, the veins represent cylindrical tubes, slightly knotted on those parts of their course which correspond to their valves, but they are rarely distended as the arteries are; the only exceptions are found in the venous polyhedral spaces or *sinuses* in the dura mater. Veins offer the same collective form as the arteries, the general volume of the venous ramifications being as much more developed as they are distant from the heart, so that all the branches collected at last into an imaginary single canal would form a hollow cone, the apex of which would correspond to the auricles.

Number and Capacity.—In comparing the two orders of vessels with reference to their *number* and *capacity*, we discover notable differences. The veins are more numerous than the arteries, as a great number of the latter are accompanied by two of the former, and the subcutaneous veins have no representatives in the arterial system. All the veins being, besides, much more voluminous than the corresponding arteries, it follows that the total capacity of the venous system much surpasses that of the arterial system, and that we may consider the relation of two to one as being the approximate expression of this difference.

When the veins are compared with the arteries, it is remarked that the relations between the length of the trunks and branches are reversed. In the arteries, the trunks are large and the branches short; in the veins, on the contrary, the branches are relatively much longer than the trunks. This disposition favours the flow of the blood in the veins, at the commencement of which we do not find, as in the arteries, a propelling organ.

Another arrangement to answer the same end, in opposing the influence that atmospheric pressure might have on the veins, is the attachment of these vessels to the walls of the cavities they pass through; this is observed, for instance, at the entrance to the thorax.

This disposition, so favourable to the circulation of the blood, becomes a constant source of danger to the surgeon, by its permitting the introduction of air into the circulatory system—especially during inspiration—when a vein is opened.

Internal Conformation.—The interior of the veins is remarkable for the presence of valvular folds, the arrangement of which resembles, in principle, that of the sigmoid valves of the heart. These *valves* offer: an adherent border attached to the walls of the vessel; a free, semilunar border; a concave surface towards the heart when the valves are tense; and a convex surface which, on the contrary, looks towards the roots of the veins.

These valves are most frequently single, but they are sometimes joined in twos or threes; according to some authorities, there are even found four or five together, arranged in a circular manner. They are distinguished as *parietal* and *ostial valves*, the latter being placed at the entrance of one vein into another. All the veins are not provided with them, however, and where they exist they may be more or less numerous. They are absent in the pulmonary system, and in the trunks of the venæ cavæ; absent or quite rudimentary throughout the extent of the vena portæ; rare and slightly developed in the vena azygos, the veins of the testicle, uterus, and ovary; and very numerous, very large, and very complete in the veins of the limbs.

The function of these valves is to favour the onward course of the blood, and to oppose its reflux from the heart towards the organs. Applied, as they are, to the walls of the veins by their concave face during the regular and normal circulation, they are disposed as a transverse valve to sustain the column of blood when any strain or pressure gives that column a retrograde movement.

Structure.—The walls of the veins are thin, semi-transparent, and elastic, and collapse when the vessels are empty. Compared with the arteries, they have only two distinct tunics.

The *internal tunic* is composed of an endothelial layer of irregular and polygonal cells, lying on a layer of connective tissue, limited by an elastic layer —analogous to the internal elastic layers of arteries.

The external tunic is composed of connective tissue, elastic fibres, and smooth muscular fibres—the first predominating.

The muscular fibres are transversal, longitudinal, or oblique, their arrangement varying with the vessels. Lorge states that the vena portæ and intralobular veins in the Horse have only longitudinal muscular fibres.

In some veins or portions of a vein they may be absent. In the veins of the bones, and in the sinuses of the dura mater, the walls are reduced to a layer of endothelium laid on a layer of connective tissue.

The venules differ from the arterioles in the dissemination of their muscular fibres, which form a continuous layer in the latter.

The veins have very numerous *vasa vasorum*, which form a complete network around them. The vena portæ alone is accompanied by *nerve filaments* from the great sympathetic.

(As remarked, the superficial veins are generally unaccompanied by arteries; they usually pass between layers of superficial fascia, and at the most convenient situations—generally those best protected—pass through the underlying fascia to terminate in the deep veins. These are most frequently accompanied by arteries, being often enclosed in the same sheath with them, particularly in the extremities. With a large number of arteries there are two veins, one on each side, the *venæ comites*, though the largest arteries have only one venous trunk. The large and frequently repeated communications are undoubtedly intended to compensate for the thinness of their parietes, which expose to obstruction and dilatation; this they cannot overcome, because of the slowness with which the blood passes through them. The valves are accessory to these inosculations; upon the cardiac face of each valve the vein is expanded into two sinuses, which correspond to the extent of the valve; these pouches give the distended vessel its nodulated appearance. Remak found longitudinal muscular fibres in the *adventitia* of the large veins of the **Ox** and **Sheep**, but chiefly in the hepatic portion of the posterior vena cava and the veins of the liver.

It is also stated that these longitudinal fibres are found in the inner part of the middle coat—for some authorities still describe three tunics—of some veins —iliac, femoral, umbilical; and the veins of the pia mater, brain, and spinal cord, retina, and placenta, as well as those of the bones and dura mater sinuses, have no muscular tissue at all. Valves are absent in the veins of the viscera, of the cranium and vertebral canal, and umbilical vein, in addition to the precited vessels. The endothelial cells on the side of the valves over which the blood passes, are more elongated than on the cardiac side of the valves, where the long axes of the cells are placed transversely—an arrangement which diminishes friction.)

Injection of the Veins.—To render the dissection and study of the veins more easy, they ought to be filled with tallow or any other solidifiable matter, like the arteries. But to attain this result the same mode of procedure cannot be employed as for them. Instead of causing the injecting material to flow from the trunk into the branches, it is necessary to propel it from the branches towards the trunk, because of the presence of the valves; this is to be done by successively fixing the cannula into several venous branches.

Four injections generally suffice to fill the whole venous system in a satisfactory manner. The first is made from the alveolar vein, beneath the masseter muscle; the second from a digital vein of one or both anterior limbs, or from the side of the foot, after having destroyed by a stylet the few valves which are sometimes found towards the point of union in this vein; or from the side of the heart. The third, from the posterior digital veins, in the same way; the fourth, by an intestinal vein. If any important veins are empty after these four injections—a case of frequent occurrence—they can be directly injected.

CHAPTER II.

Veins of the Lesser Circulation, or Pulmonary Veins (Fig. 349, *f*).

The pulmonary veins comport themselves in a similar manner to the corresponding arteries. They are lodged in the substance of the lung, and collect in from four to eight trunks, which open into the roof of the left auricle, after emerging from the pulmonary organ immediately above the origin of the bronchi. As they are destitute of valves, they readily allow the blood to flow towards their roots. It is they which carry to the left heart the blood thrown into the lungs by the right ventricle, to be submitted to the revivifying action of the atmosphere.

CHAPTER III.

Veins of the General or Systemic Circulation.

These vessels bring to the right auricle the blood which has been dispersed in the texture of organs, by the ramifications of the great arterial tree.

They open into the auricle by forming three groups—the *coronary* or *cardiac veins*, the *anterior vena cava*, and the *posterior vena cava.*

The diaphragm establishes the exact limit between the domains of the anterior and posterior vena cava.

Article I.—Cardiac or Coronary Veins.

There are several *small*, and one *large* or *great coronary vein.*

Small Cardiac Veins.—These are the almost insignificant vessels, undetermined in number, which come from the walls of the right ventricle and open directly into the corresponding auricle at the coronary groove. (Among these may be included the debatable *venæ Thebesii*—a multitude of minute venules said to arise in the structure of the heart, and open directly into its cavities.)

Great Coronary Vein (Figs. 349, 5; 350, *o*, *p*).—This vein is formed by two roots: one is lodged in the right ventricular groove, and accompanies the cardiac artery of the same side; the other follows, at first, the left ventricular groove, ascends nearly to the pulmonary artery, and is then inflected backwards by placing itself in the coronary groove, along with the horizontal branch of the left cardiac artery. Turning round the base of the posterior ventricle, it joins the right root, near the upper extremity of its groove. The common trunk resulting from this junction, after a short course opens into the right auricle, below and within the entrance of the posterior vena cava.

In their course, the two branches of the coronary vein receive branches from the auricular and ventricular walls.

The *bronchial veins*, ramifying on the bronchi like the arteries, the satellites of which they are, also open into the great coronary vein, very near its entrance, after becoming a single vessel, which sometimes passes directly into the auricular cavity.

ARTICLE II.—ANTERIOR VENA CAVA (Figs. 349, *r*; 350, *d*; 389).

This is a voluminous trunk, which ought to be considered as the corresponding vein of the anterior aorta. It extends from the entrance of the chest to the right auricle, into the roof of which it is inserted. It is comprised between the two layers of the anterior mediastinum, and lies below the trachea, to the right of the anterior aorta.

Four large vessels—the *two jugular* and *two axillary veins*—opening in common in the space comprised between the two first ribs, constitute the roots of this vessel.

COLLATERAL AFFLUENTS.—The affluent vessels which the anterior vena cava receives in its course are: the *internal thoracic*, *vertebral*, *superior cervical*, and *dorsal veins*, and the *great vena azygos*.

Internal Thoracic or Internal Mammary Vein.—A satellite of the artery of the same name, this vein opens into the anterior vena cava, at its origin (Fig. 389).

Vertebral Vein.—It accompanies the corresponding artery in the canal formed by the foramina in the transverse processes of the cervical vertebra, and joins the vena cava at the origin of that artery (Fig. 389).

Superior Cervical Vein.—Exactly resembles the artery the name of which it bears.

Dorsal Vein.—This vessel follows the dorso-muscular artery, and, like it, presents a *subcostal* branch. On the left side, this branch is designated the *small vena azygos*, and is often prolonged to the eleventh or twelfth rib; it receives the intercostal veins of the spaces it crosses.

It may be remarked that the vertebral, superior cervical, and dorsal veins of the right side, are nearly always thrown separately into the vena cava, while on the left side they constantly unite to form a single trunk (Figs. 349, *u*; 389).

Great Vena Azygos (Figs. 349, *x*; 350, *e*; 389).—This is a long single vein, which commences at the first lumbar vertebra, and extends forward on the right of the anterior aorta, beneath the bodies of the dorsal vertebræ to about the sixth, when it is inflected downward to terminate in the anterior vena cava, near the entrance of that vessel, or even directly into the right auricle.

In its course, the great vena azygos is maintained against the bodies of the dorsal vertebræ by means of the parietal pleura; it runs alongside the outer border of the thoracic duct, which separates it from the aorta.[1] The terminal

[1] Sometimes the azygos is situated between the aorta and the thoracic duct. When the latter lies to the left side, it is in direct contact with the posterior aorta.

extremity of its inflection crosses the œsophagus and trachea to the right, and is included between these two tubes on the one side, and the right layer of the mediastinum on the other.

Its roots are some branches emerging from the spinal and psoas muscles, and which are not usually in direct communication with the posterior vena cava, as in Man and the other animals.

During its progress, it receives the first lumbar and the satellite veins of all the aortic intercostal arteries, right and left. But when the small vena azygos is prolonged backwards beyond the posterior extremity of the subcostal artery, that vessel, as we have already seen, forms the confluent of a certain number of left posterior intercostals.

Jugular Veins (Figs. 386, 389).

The jugular is a satellite vein of the carotid artery.

Origin.—It commences behind the inferior maxilla, below the articulation of the jaw, by two large roots—the *superficial temporal vein* and the *internal maxillary vein*, which correspond to the two terminal branches of the external carotid artery.

Situation—Direction.—This vessel passes downward and backward, lodged at first in the substance of the parotid gland, afterwards in the muscular interspace designated the *jugular furrow*, which is comprised between the adjacent borders of the mastoido-humeralis and sterno-maxillaris muscles. Reaching the inferior extremity of the neck, it terminates in the following manner :—

Termination.—On arriving near the entrance to the chest, the two jugulars unite in forming a vessel named the *confluent of the jugulars.* This confluent, into which open the two axillary veins, is comprised between the two first ribs, and situated below the trachea, in the middle of the prepectoral lymphatic glands. Fixed by fibrous bands to the neighbouring parts, and particularly to the two first ribs, the walls of the jugular confluent do not collapse when the venous system is in a state of vacuity—an anatomical peculiarity which it is necessary to understand, in order to explain the manner in which air obtains entrance into the circulation when the jugular or axillary veins are opened, as well as affording an indication how to prevent this serious accident.

Relations.—At its upper extremity, the jugular vein is surrounded by the parotideal tissue. For the remainder of its extent, it is covered externally by the cervical panniculus, and by the branches of the cervical plexus which creep on the external surface of that muscle. Inwardly, its relations vary as we consider its situations, above or below : above, it is related to the subscapulo-hyoideus muscle, which separates it from the common carotid and its satellite nerves ; in its inferior moiety, it is in direct relation with that vessel, which is above it, as well as with the trachea, and even, though only on the left side, with the œsophagus.

Collateral Affluent Vessels.—The collateral veins which go to the jugular from its origin to its termination, are : 1. *Maxillo-muscular veins.* 2. *Posterior auricular vein.* 3. *Occipital vein.* 4. *Submaxillary* or *facial vein.* 5. *Thyroid vein.* 6. *Cephalic vein.* 7. *Parotideal* and *innominate muscular branches.*

A. Maxillo-muscular Veins.—Two in number, corresponding to the branches of the artery of the same name, and entering the jugular close to its origin, either separately or after forming a common trunk.

B. **Posterior Auricular Vein.**—A voluminous vessel which commences on the concha, and descends on the external face of the parotid gland, near its posterior border, where it is joined by numerous divisions from the parotid lobules. It opens into the jugular vein, generally a little below, and opposite to, the maxillo-muscular vessels, though it is sometimes lower—often even after the occipital vein (Fig. 385, 13).

C. **Occipital vein.**—The occipital vein corresponds, in every respect, to its fellow-artery. It has two roots—an anterior, which originates at the posterior extremity of the subsphenoidal confluent ; and a posterior, commencing beneath the transverse process of the atlas, and formed by three principal branches.

Among the branches of the latter root, one passes with the retrograde artery through the posterior foramen of the atlas, and constitutes, as it were, the origin of the vertebral vein ; the second communicates with the occipito-atloid sinuses, by traversing the atlas near its middle ; the third—satellite of the cerebro-spinal artery—comes also from these sinuses, and receives the venules which accompany the ramifications of the occipito-muscular artery.

D. **Sub-maxillary or Facial Vein.**—A satellite of the artery of the same name, this vessel begins on the forehead by two roots—a superior and inferior, analogous in every point to the terminal branches of the artery. It descends along the anterior border of the masseter muscle, gains the maxillary fissure, into which it is inflected, placing itself between the artery and Steno's duct ; then proceeds backwards and downwards on the internal pterygoid muscle, always accompanied by the glosso-facial artery until near the anterior extremity of the maxillary gland, when it leaves it to follow the inferior border of that gland, and enters the jugular vein, after crossing the sterno-maxillaris muscle outwardly, and forming with the latter vein an angle which is occupied by the inferior extremity of the parotid gland (Fig. 385).

Branches of origin.—Of the two branches which, by their union, constitute the origin of the submaxillary vein, the inferior (*dorsalis nasi*)—a satellite of the nasal branch of the corresponding artery—possesses no interest. The superior, or *angular vein of the eye*, merits particular notice, as venesection is sometimes practised on it. It arises near the nasal angle of the eye, and creeps to the external face of the elevator muscle of the upper lip, below the lachrymalis muscle.

Collateral branches.—In its progress, the submaxillary vein receives a great number of affluents, the principal of which are the *alveolar vein*, the *labial or coronary veins*, the *buccal vein*, and the *sublingual vein*.

a. Alveolar vein (*vena varicosa*).—This is a considerable vessel lodged beneath the masseter, and lying against the supermaxillary bone, between the zygomatic crest and the aveoli of the upper molar teeth (Fig. 385).

The arrangement of this vessel is most singular ; its anterior extremity opens into the submaxillary vein, and its posterior extremity traverses the ocular sheath, receives the ophthalmic veins, and passes, with the ophthalmic nerve of the fifth pair, into the foramen lacerum orbitale, to open into the cavernous sinus in the interior of the cranium.[1]

Before traversing the ocular sheath, and towards the maxillary hiatus, this vein receives the *superior dental* and the confluent of the *nasal veins*—vessels

[1] We have also seen it send into the subsphenoidal canal, to the inner side of the internal maxillary artery, a slender branch that joined the anterior extremity of the subsphenoidal confluent. But we cannot say that this disposition is constant.

which emerge from the bony orifices traversed by the arteries of the same name —that is, the maxillo-dental canal and the nasal foramen. It also receives the confluent of the *palatine veins*, which pass by the palatine groove, instead of coursing along the palatine canal with the corresponding artery. In general, these three branches do not join the alveolar vein separately, but rather by a common trunk.

The alveolar vein does not present a uniform volume. It increases until it reaches the alveolar tuberosity, where it forms a kind of large reservoir; but in traversing the ocular sheath it suddenly becomes constricted, and maintains a small diameter until its entrance into the cavernous sinus. (The reservoir is supposed to prevent congestion of the cavernous sinus.)

This vein may be considered as an affluent of the sinuses of the dura mater, as well as of the external maxillary vein.

b. Labial or coronary veins.—Satellites of the labial arteries. The *superior* is often rudimentary. The *inferior*, always voluminous, is constituted by the union of several anastomotic branches lying against the external face of the mucous membrane of the cheek.

c. Buccal vein.—Among the affluents of the external maxillary vein, we cite this, because it opens into the latter by its anterior extremity, opposite the inferior coronary vein, with which it sometimes communicates by a particular branch. But the buccal vein, properly speaking, constitutes the root of the internal maxillary, and we will describe it as such.

d. Sublingual vein.—A large vessel, formed of two branches, which arise in the substance of the tongue, and pass sometimes separately into the internal maxillary vein. This sublingual vein passes through the mylo-hyoideus muscle, from within to without, and joins the principal vessel at the lymphatic glands lodged in the submaxillary space.

E. **Thyroid Vein.**—This is a voluminous trunk, resulting from the union of the venous divisions which accompany the laryngeal and thyroid branches of the thyroid or thyro-laryngeal artery. It joins the jugular beside the submaxillary vein, and most frequently above it.

F. **Cephalic or Plate Vein.**—A superficial vessel, which represents one of the terminal branches of the principal subcutaneous vein of the forearm. It is lodged in the interspace of the mastoido-humeralis and anterior superficial pectoral muscles, and enters the inferior extremity of the jugular vein (Fig. 389).

G. **Innominate Veins.**—A certain number come from the parotid gland, but the principal arise in the muscles of the neck and withers. One of the latter accompanies the superior branch of the cervico muscular-artery.

Roots of the Jugular Vein.

These are constituted by the *superficial temporal* and *internal maxillary veins*, which are chiefly supplied by the *sinuses* of the cranial dura mater.

1. Superficial Temporal Vein.

Corresponding in the most exact manner to the temporal ~~vein~~ artery, this vessel is lodged behind the posterior border of the maxilla, near the articulation of the jaw, beneath the parotid gland, and is embedded in its tissue.

From the union of these two roots, there results:

1. The *anterior auricular vein*—a very large, often multiple, and reticulated

branch, anastomosing with the pterygoid branches of the internal maxillary artery. This vein issues from the parieto-temporal conduit, behind the supra-condyloid eminence; it receives one or two branches which escape from this conduit by the foramina in the temporal fossa, crosses the temporalis muscle, and is charged with venules which arise in the interior of that muscle, as well as in the textures of the external ear (Fig. 385, 8).

2. The *subzygomatic vein*, a satellite of the homonymous artery, and, like it, is divided into two branches—one accompanying the transverse artery of the face, the other the masseteric artery. The latter branch communicates by its inferior extremity with the external maxillo-muscular vein; it joins, by its other extremity, an enormous branch which comes from the temporal muscle, and which passes into the sigmoid notch, after anastomosing largely with the deep temporal branches of the internal maxillary vein (Fig. 385, 6).

2. Internal Maxillary Vein.

Remarkable for its enormous volume, this vein creeps between the internal masseter muscle and the maxilla, in an oblique direction upwards and backwards. Arriving within the articulation of the jaw, a little below the maxillary condyle and the external pterygoid muscle, it joins the temporal vein after being slightly inflected downwards. It therefore runs its course at a certain distance from the corresponding artery.

The internal maxillary has for its radicle the *buccal vein*, which it succeeds near the superior extremity of the bucciuator muscle.

Satellite of the artery and nerve of the same name, this buccal vein, remarkable for its volume, is situated beneath the masseter muscle, near the inferior border of the buccinator muscle; by its anterior extremity it communicates directly with the internal maxillary vein, nearly opposite to the junction of the inferior coronary vein; its posterior extremity is continued directly with the internal maxillary vein. The collateral branches it receives in its course, come from the masseter muscle and the parietes of the cheek.

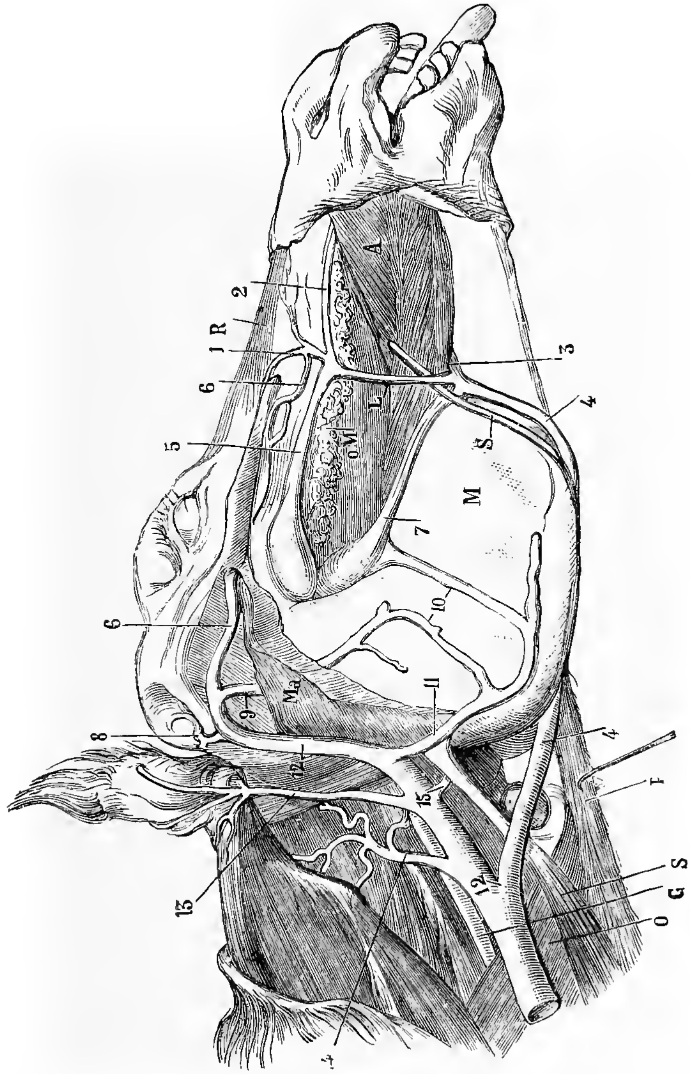
On its way it receives a great number of affluents; these are:

1. A large *lingual vein*, accompanying the small hypoglossal nerve.
2. The *inferior dental vein*.
3. The *trunk of the deep temporal veins*—a large vessel situated in front and to the inside of the temporo-maxillary articulation, where it communicates with the masseteric vein. This vessel arises in the texture of the temporalis muscle, but particularly in the parieto-temporal confluent, with which it joins through the foramina in the temporal fossa.
4. The *pterygoid veins*, numerous branches, only a portion of which come from the pterygoid muscles. The others, arising from the subsphenoidal confluent of the sinuses of the dura mater, form, on the superficial face of the external pterygoid muscle, a wide-meshed network which communicates posteriorly with the temporal vein, and anteriorly with the confluent of the deep temporal veins. But as these two vessels are bound together, outside the temporo-maxillary articulation, by means of the masseteric artery, it results that this articulation is enlaced on every side by one of the richest venous plexuses in the whole body (Fig 386, 10).

3. Sinuses of the Dura Mater.

We will here describe not only the sinuses of the cranial dura mater which supply the radicles of the jugular vein, but also those of the spinal dura mater, although these empty themselves into other veins; in order that we may

Fig. 385.



RADICLES AND COLLATERAL BRANCHES OF THE JUGULAR VEIN IN THE HORSE (EXTERNAL VIEW).

M, Inferior maxilla; A, buccinator; Mo, superior molar gland; Ma, masseter muscle (the greater portion has been removed); R, elevator of the upper lip; S, Steno's duct; C, carotid artery; O, subscapulo-hyoideus muscle; St, sterno-maxillaris muscle; P, termination of the two previous muscles. 1, Radicles of the facial vein; 2, superior coronary vein; 3, inferior coronary vein; 4, 4, 4, facial vein; 5, alveolar vein; 6, 6, transverse facial vein communicating in front with the facial vein; 7, buccal vein; 8, anterior auricular vein; 9, masseteric vein; 10, deep network of the masseteric veins; 11, maxillo-muscular vein; 12, 12, jugular vein; 13, posterior auricular vein; 14, occipital vein and its various branches; 15, laryngeal vein.

be able to consider, in their entirety, all the vessels of the nervous centres which carry dark blood.

The Sinuses of the Dura Mater in General.—These are vascular spaces in the texture of the dura mater, or situated between that membrane and the bones which form the walls of the cerebro-spinal sheath, or are even excavated on the inner surface of these bones. These spaces differ more particularly from the veins, by their being generally of a prismatic form, by being continually open, by the absence of valves in their interior, and by the presence, in some of them, of lamellæ (*trabeculæ*), or intersecting filaments (*chordæ Willisii*) which stud their inner surface, and make them look reticulated.

Their walls are reduced to an epithelial layer that lies either on the dura mater, or on the osseous tissue.

It is into these sinuses that the veins of the brain and spinal cord disgorge themselves.

The Sinuses of the Cranial Dura Mater in Particular.—Four principal will be described: the *superior longitudinal sinus of the falx cerebri*, or *median sinus*, the *two cavernous or sphenoidal sinuses*, and the group of *occipito-atloid sinuses*.

1. **Sinus of the Falx Cerebri, Superior Longitudinal or Median Sinus.**—Channeled in the substance of the falx cerebri, and becoming wider as it extends backwards, this sinus commences near the crista galli process, and terminates on the internal parietal protuberance by bifurcating. The two branches resulting from this division form the origin of the parieto-temporal confluent, or *winepress of Herophilus* (*torcular Herophili*, Fig. 386, 1, 4).

2. **Cavernous or Supra-sphenoidal Sinuses.**—These are two in number —a right and a left. They occupy, on the internal face of the sphenoid bone, at each side of the sella Turcica, the so-called cavernous fissures. Bordered outwardly by the superior maxillary nerve, they receive at their anterior extremity the insertion of the alveolar vein. Posteriorly, they join each other, and in doing so form a kind of arch, open in front, around the pituitary gland (Fig. 386, 8). Each opens widely at the foramen lacerum basis cranii, into the subsphenoidal confluent.

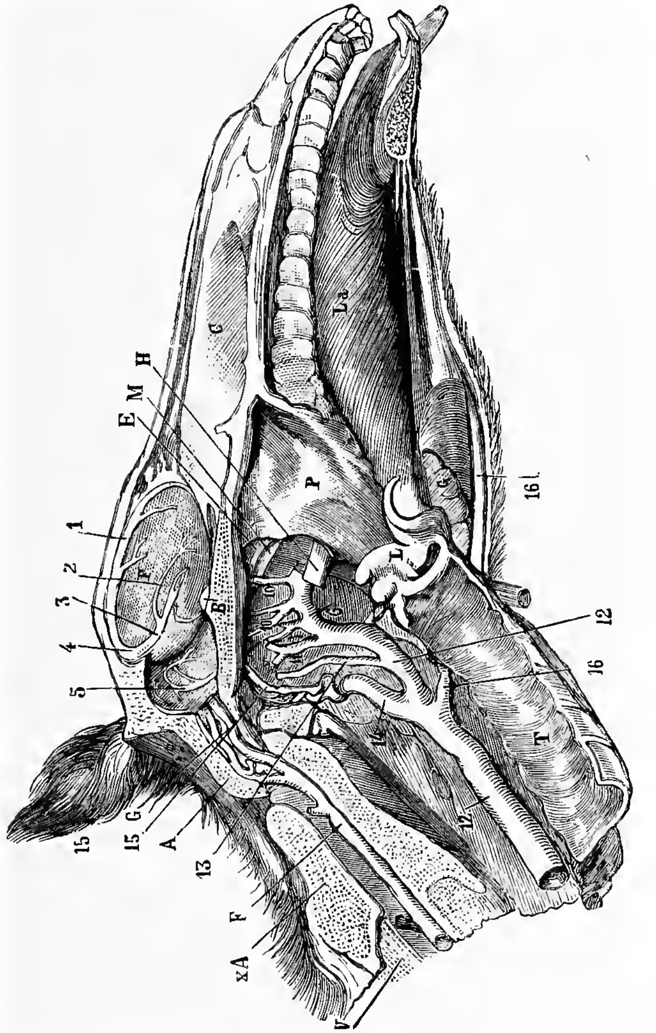
3. **Occipital or Occipito-atloid Sinuses.**—By this name is designated a network of large irregular veins, situated beneath the external face of the dura mater, on the sides of the occipital foramen, and on the entire internal surface of the atloidean ring. Anteriorly, these venous reservoirs communicate, through the condyloid foramen, with the posterior extremity of the subsphenoidal confluent. Posteriorly, they are continuous with the spinal sinuses, of which we may consider them to be the origin (Fig. 386, 6).

4. **Rudimentary Sinuses of the Cranial Dura Mater.**—Independently of the above-described reservoirs, there exists, on the inner wall of the cranium, some rudimentary venous sinuses which should be indicated; these are: 1. One or two veins lodged in the structure of the tentorium cerebelli, designated the *petrosal* or *transverse sinuses*, communicating, below, with the cavernous sinuses, and entering, above, into the parieto-temporal confluent.[1] 2. Some small, irregular, and reticulated cavities, very variable in their disposition, situated beneath the dura mater, on the sides of the cerebellar cavity, and which generally empty themselves into the subsphenoidal confluent by traversing the posterior part of the foramen lacerum basis cranii, and also opening sometimes into the petrosal sinus; these cavities may be regarded as the representatives of

[1] More frequently, perhaps, these veins arise directly from the substance of the brain, and do not communicate, below, with the cavernous sinuses.

the *lateral sinuses* in Man (Fig. 386, 5). 3. In some instances, an *inferior median sinus*, channeled near the free border of the face of the brain, passes behind into the torcular Herophili (Fig. 386, 2).

Fig. 386.



SINUSES OF THE DURA MATER AND RADICLES OF THE JUGULAR VEIN OF THE HORSE, SEEN IN A MEDIAN AND LONGITUDINAL SECTION OF THE HEAD.

A, Atlas; Ax, axis; V, third cervical vertebra; C, nasal septum; P, pharynx; E, Eustachian tube; M, inferior maxillary nerve—cornu of the os hyoideus; La, tongue; L, larynx; T, trachea; G, submaxillary salivary gland; F, falx cerebri. 1, Sinus of ditto; 2, middle inferior sinus; 3, venæ Galeni; 4, torcular Herophili; 5, small sinuses of the cerebellar cavity; 6, occipito-atloidean sinus; 7, spinal sinus; 8, communicating branch of the cavernous sinuses; 9, internal maxillary vein receiving above; 10, 10, 10, the pterygoid veins; 11, trunk of the temporal veins; 12, 12, jugular vein; 13, posterior auricular vein; 14, occipital vein; 15, radicle of the occipital vein arising from posterior extremity of the subsphenoidal confluent; 16, 16, facial vein.

The Spinal Sinuses in Particular.—We thus designate in Veterinary Anatomy—and with good reason—two series of venous reservoirs which are found throughout the whole extent of the vertebral column, on the sides of the roof of the spinal canal. Lodged in the lateral depressions on the superior face of the vertebral bodies, at the side of the common superior vertebral ligament, and covered by the dura mater, these reservoirs, continued from one vertebra to the other, are like two large, irregular, parallel veins, which commence at the atlo-axoid articulation, terminate on the first coccygeal vertebræ, where their presence is yet well defined, and communicate with one another during their course by transversal anastomoses (Fig. 386, 3).

Affluent Veins that open into the Sinuses of the Dura Mater.—These are the vessels which carry blood either from the dura mater itself, or from the substance of the nerve-centres : those of the first category are rare, but the second are numerous. Although we are unwilling to make a detailed study of the latter, we must nevertheless notice what is most remarkable in their disposition.

a. On the brain, the veins form a much richer and closer network than that of the arterial ramifications ; from this network proceed a certain number of principal branches, which throw themselves into the sinuses of the cranial dura mater. The veins of the cerebrum, for the most part, gain the median and transverse sinuses ; a few only pass into the cavernous sinuses. Those of the medulla oblongata and cerebellum go to the petrosal and occipital sinuses.

With regard to the internal veins of the brain—those which, by their interlacing, constitute the choroid plexus—they unite into a large trunk—the *great vein of the brain*, or *vena Galeni*, which bends round the superior extremity of the corpus callosum, reaches the interlobular fissure, and enters the falciform or middle sinus, near its posterior end, after receiving the superficial veins from the inner face of the hemispheres.

b. The venules arising from the spinal cord are also very remarkable for the fine network they form on the surface of the organ. They collect into a common trunk—the *median spinal vein*, which runs from before to behind, throughout the whole extent of the superior groove in the spinal cord ; thus occupying an analagous, though opposite, position to that of the artery of the same name. From this vein escape, at intervals, emergent branches which open into the spinal sinuses.

Effluent Canals of the Dura Mater Sinuses.—We have to notice, under this designation, the veins which carry the blood from the sinuses, and will consider in succession those which commence at the cranial sinuses, as well as those that emerge from the interspinal canals.

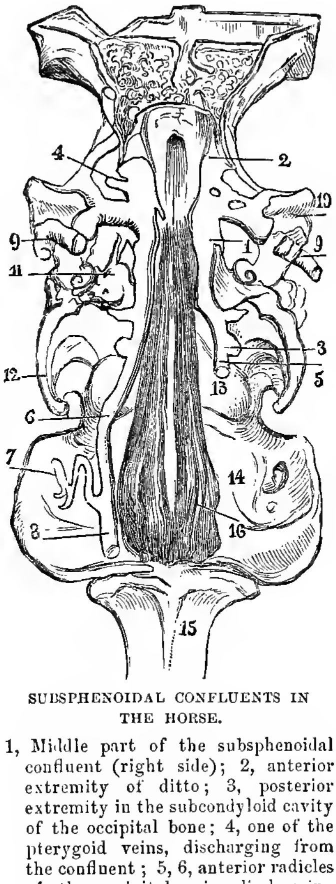
a. To be carried from the cranial sinuses, the blood flows into two kinds of double gulfs, known as the *parieto-temporal* or *subsphenoidal confluents.*

The *parieto-temporal confluents* are lodged in the canals of the same name, along with the mastoid artery. Each commences at the base of the internal parietal protuberance, and terminates behind the supra-condyloid eminence. The median and transverse sinuses are confounded with the superior extremity of these reservoirs, and empty into them the blood coming from the encephalic mass. This fluid is subsequently taken away by the superficial and deep temporal veins, which have their principal radicles in these confluents.

In **Ruminants**, the parieto-temporal confluent opens into the temporal veins, and has in front a branch that passes to the foramen lacerum basis cranii. In the **Pig** and **Cat**, it is lodged in the two grooves which open, one at the anterior foramen lacerum, the other at the posterior.

The *subsphenoidal confluents* (Fig. 387) extend on the sides of the body of the sphenoid bone and basilar process, from the base of the subsphenoidal process to the condyloid fossa, concurring in the closing of the occipito-spheno-temporal hiatus. They open at their middle portion into the corresponding cavernous sinus, by an oval aperture which the internal carotid artery traverses in penetrating into the cranium. The anterior extremity terminates in a *cul-de-sac*. Posteriorly, they communicate through the condyloid foramina with the occipital sinuses. The vessels which carry off the blood from these confluents are the pterygoid veins, and the anterior radicle of the occipital vein. We know that the posterior branch of the latter vessel removes the blood directly into the occipital sinuses.

Fig. 387.



SUBSPHENOIDAL CONFLUENTS IN THE HORSE.

1, Middle part of the subsphenoidal confluent (right side); 2, anterior extremity of ditto; 3, posterior extremity in the subcondyloid cavity of the occipital bone; 4, one of the pterygoid veins, discharging from the confluent; 5, 6, anterior radicles of the occipital vein, discharging from the confluent; 7, posterior radicle of the left occipital vein; 8, occipital vein; 9, 9, temporal veins, discharging from the parieto-temporal confluents; 10, temporal condyle; 11, tuberosity of the temporal bone; 12, styloid process of the occipital bone; 13, condyle of ditto; 14, atlas; 15, axis; 16, rectus capitis anticus muscle.

b. The emergent veins of the spinal sinuses present a more simple disposition. At each intervertebral space arise several branches, which more particularly make their exit by the intervertebral foramina to join the neighbouring veins; in the cervical region, the vertebral veins serve as a receptacle in this way for the venous branches from the spinal sinuses; in the dorsal region, it is the spinal branches of the intercostals; in the loins, the analogous branches of the lumbar veins; and in the sacral region, the lateral sacral vein.

As a whole, the venous system of the cerebro-spinal centres presents a special physiognomy. The veins arising from the nerve substance or the meninges, instead of passing immediately into the veins of the neck or head, open at first into irregular cavities (*sinuses*) established between the cranium and the membranes enveloping the nervous centres, or excavated in the cranial walls. The blood collects in certain of these cavities, named *confluents*, whence the vessels go which finally open into the deep or superficial veins of the cervical region. There are, therefore, two stages between the veins of the brain or spinal cord and the veins of the neck and face—the sinuses and confluents.

Axillary Veins.

A general confluent of all the veins of the thoracic limb and of some from the trunk, the axillary vein commences beneath the scapulo-humeral articulation, towards the terminal extremity of the corresponding arterial trunk, accompanying the latter to the entrance of the chest, and joining the confluent of the jugulars to constitute, with these two vessels, the inferior vena cava (Fig. 389, 18).

In studying, from their origin to their termination, the numerous branches which concur in the formation of this venous trunk, we recognize :—

1. That they form in the foot a very rich network, from which proceed the *digital veins*, satellite vessels of the homonymous arteries.

2. That to these digital veins, which are united in an arch above the sesamoids, succeed three *metacarpal branches*, or *collaterals of the cannon*—two *superficials*, placed on each side of the flexor tendons, and a *deep* vein, situated underneath the suspensory ligament, along with the interosseous arteries.

3. That the metacarpal veins also open into each other, in the superior and posterior region of the carpus, to form, on again separating, two groups of *antibrachial veins:* one group comprising the *ulnar* and the *posterior* or *internal radials*, which accompany the arteries of the same name ; the other, constituted by a single subcutaneous branch—the *median vein*—which receives at its superior extremity the *anterior superficial radial vein.*

4. That at the ulnar articulation, these two groups of antibrachial veins join the satellite vessel of the *anterior radial artery*, and communicate by a very complicated system of anastomoses, from which results a principal trunk—the *humeral vein.*

5. That the *humeral vein*, after receiving on its course several muscular branches and the *subcutaneous thoracic vein*, unites near the shoulder-joint with the *brachial* or *subscapular* trunk, to form the axillary vein.

We will study all these branches in the inverse order of their enumeration.

1. Brachial or Subscapular Vein.

A very considerable vessel, the arrangement of which resembles that of the subscapular artery, though presenting some special peculiarities which do not merit much attention ; for example, it most frequently receives the satellite vein of the prehumeral artery.

2. Humeral Vein.

Placed behind and to the inner side of the humeral artery, this vessel commences above the articulation of the elbow, being formed at this point by the anastomosing system of veins from the forearm, and terminates below the shoulder-joint in opening into the subscapular vein.

Independently of the subcutaneous thoracic vein, which will be studied in a special manner, the humeral vein receives on its way several collateral satellites of the branches emanating from the humeral artery. One of these, the *epicondyloid*, is only a continuation of the ulnar vein.

Very often we find a second humeral vein in the deep region of the arm ; this is an accessory vessel, parallel to the preceding, and situated opposite it, in front of the artery.

3. Subcutaneous Thoracic or Spur Vein.

This vein, which is important to know, as bleeding is sometimes practised from it, commences on the flank and belly by numerous superficial divisions, which unite in two principal radicles and afterwards become a single trunk, placed in the substance, or on the external surface of the panniculus carnosus, where it is directed forwards in following the superior border of the posterior superficial pectoral muscle, accompanied by an arterial ramuscule and a thick nerve. It insinuates itself beneath the olecranian muscles, and finally terminates in the humeral vein by joining the branch that follows the deep muscular artery.

4. Deep Veins of the Forearm.

A. **Anterior Radial Vein.**—This follows the same track, and affects the same variations, as the corresponding artery.

B. **Posterior Radial Veins.**—The posterior radial artery is always accompanied, and, as it were, enveloped, by a fasciculus of three or four venous branches, which frequently anastomose with each other, and are reinforced by collateral branches, among which the *interosseous vein* must be noted.

These radial branches commence above the carpus, by continuing the metacarpal veins. They concur to form the humeral vein, in joining the other antibrachial veins at the inferior extremity of the arm.

C. **Ulnar Vein.**—This vessel is lodged, with the nerve and small artery of the same name, in the interspace between the oblique and internal flexors of the metacarpus. A number of muscular and subcutaneous branches enter this vein.

It has the same origin as the posterior radial veins. Its superior or terminal extremity bends forward, close to the trunk of the ulnar artery, and goes to the inferior extremity of the humeral vein. Frequently the ulnar vein is double in the latter portion of its track, and between these two branches lies the artery. It always communicates at this point, by one or more branches, with the deep muscular vein.

5. Superficial Veins of the Forearm.

Placed outside the fibrous sheath formed by the antibrachial aponeourosis, these veins, which are principally two in number, are maintained against the external face of that membrane by a thin fascia that separates them from the skin.

A. **Median or Internal Subcutaneous Vein** (Fig. 389, 31).—This is also one of the vessels selected for the operation of phlebotomy. It is the continuation of the internal metacarpal vein, ascends from the inner face of the carpus to the superior extremity of the forearm, by crossing the radius in a very oblique manner, and terminates in two very large branches, the posterior of which is the *basilic vein*, and the anterior the *cephalic vein*.

The *basilic vein* traverses the superficial pectoral muscle, to aid in forming the humeral trunk (Fig. 389, 34).

The *cephalic*, or *plate vein*, crosses the superficial band of the biceps muscle, is lodged in the space comprised between the mastoido-humeralis and anterior superficial pectoral muscles, and afterwards opens in the jugular vein (Fig. 389, 35).

B. **External Subcutaneous or Anterior Radial Vein** (Fig. 389, 32).—Less considerable than the preceding, this vein arises at the carpal region, in its course occupies the anterior face of the forearm, and terminates in uniting its superior extremity either to the internal subcutaneous, or the cephalic vein; the last is most frequently the case.

6. Metacarpal Veins.

Three in number, these veins are distinguished into *internal* and *external metacarpals* or *collaterals of the cannon*, and *deep* or *interosseous metacarpal* or *collateral*.

A. **Internal Metacarpal Vein.**—More voluminous than the others, this vein passes from the vicinity of the fetlock along the flexor tendons, accompanied by the principal artery of the cannon and the external plantar nerve, places itself in the special sheath which envelops the common trunk of the interosseous arteries to the inside of, and behind the carpus, to be continued in the antibrachial region by the internal subcutaneous vein, after communicating with the other metacarpal veins (Fig. 389, 30).

B. **External Metacarpal Vein.**—Situated opposite the preceding—to the external side of the flexor tendons, in company with the corresponding plantar nerve—this vessel follows that nerve to near the supra-carpal, and then separates into several reticulate branches which anastomose with the internal vein, from which proceed the ulnar and internal or posterior radial veins.

C. **Interosseous Vein.**—A tortuous, irregular, and sometimes multiple vessel, lodged with the plantar interosseous arteries between the suspensory ligament and the posterior face of the principal metacarpal bone. Reaching the superior extremity of that bone, it unites largely to the right and left with the external and internal metacarpals, sending upwards one or two small branches which traverse the carpal sheath along with the collateral artery of the cannon, and enter into the posterior radial branches above the knee.

7. Digital Veins.

These veins occupy, on the sides of the digital region, the same position as the homonymous arteries in front of which they are placed. They arise from the network formed on the lateral cartilages by the veins of the foot, and terminate in uniting above the fetlock, between the flexor tendons of the phalanges and the suspensory ligament, so as to form an arch (the *sesamoidean*) from which proceed the three metacarpal veins (Fig. 389, 37).

8. Veins of the Foot or Ungual Region.

The importance of the region to which these vessels belong, requires that they should be described more fully than the other veins, and as has been already done with the arteries of this part of the body. We will, therefore, borrow the exact and minute description given by M. H. Bouley.[1]

This venous apparatus may be divided into *external* and *internal* or *intra-osseous*.

a. External Venous Apparatus.

"The external venous apparatus of the digital region is very remarkable for the number, development, superficial distribution, and reticulated disposition of the canals composing it. To give an idea of this, we cannot do better than compare its general form to a net whose irregular meshes are extended over, and moulded on, the two last phalanges which are contained in it.

"This intricate reticulation of the venous apparatus of the foot is marvellously displayed in specimens injected after maceration, and then dried.

[1] *Traité de l'Organization du Pied du Cheval*, p. 65

"To facilitate its description, we recognize in it three parts distinct by their situation, though they only form a continuous one. They are:

"1. The *solar plexus.*

"2. The *podophyllous plexus.*

"3. The *coronary plexus.*

"A. Solar Plexus.—The veins of the solar plexus are remarkable for the equality of their calibre throughout the whole extent of the plantar surface, and by the almost absolute absence of anastomotic communications with the deep parts.

"Sustained in a special fibrous web (*plantar reticulum*), which replaces the periosteum at the lower surface of the phalanx, and is a continuation of the corium of the villous tissue, these veins appear indeed to have so little communication, except with each other, that it is possible to detach the *plantar reticulum* from the superior face of the third phalanx without disturbing them.

"The general disposition of the veins in the texture of the reticulum supporting them, closely resembles that of the secondary ribs of the limb (or *laminar merithal*) of certain asymmetrical leaves. In their course they follow an irregularly broken line, intercepting each other by joining at short intervals, so as to form unequal-sized, unsymmetric, polygonal spaces.

"These veins discharge themselves by a double canal—a *central*, the least considerable and least constant; the other, *peripheral* or *circumflex*, corresponding to the artery of the same name,[1] and of which it is the satellite vein.

"*Central canal.*—The central canal is formed by the simultaneous anastomoses of a crowd of venous ramifications converging towards the centre of the digit. It is of a parabolic shape, and embraces in the concavity of its curvature the point of the pyramidal body, whence it throws its two branches in a parallel manner on the sides of that body, into the bottom of the lateral lacunæ as far as the cartilaginous bulbs, where it proceeds to the external coronary plexus. This disposition is not constant, however, as specimens are frequently met with in which this central canal is replaced by multiple veins, which are more considerable than those forming the whole of the plexus, and which serve them as overfalls towards the superficial coronary plexus.

"*Circumflex or peripheral vein.*—This vein is of large calibre, and formed by divergent ramifications from the solar plexus, as well as the descending veins of the podophyllous plexus; it margins the external border of the villous tissue, in following a slightly undulous line within the circumflex artery, of which it is the satellite. It is sometimes broken up, at certain points of its course, into several smaller canals which are continuous with its trunks.

"In its circular route, all the divergent solar and descending podophyllous veins are discharged into it, and it terminates, at the extremities of the crescent formed by the third phalanx, in several large branches which pass beneath the podophyllous tissue to the lateral cartilage, where they concur to form the superficial coronary plexus.

"B. Podophyllous Venous Plexus or Network.—The veins of the podophyllous plexus exhibits a disposition analogous to those of the solar plexus; like them, they are sustained in the meshes of a fibrous texture (the *reticulum processigerum* of Bracy Clark, the *subpodophyllous reticulum* of French Veterinarians) spread on the anterior surface of the bone, in the same way as the periosteum is on other bones, and continuous with the corium of the laminal

[1] The *inferior circumflex artery of the foot.*

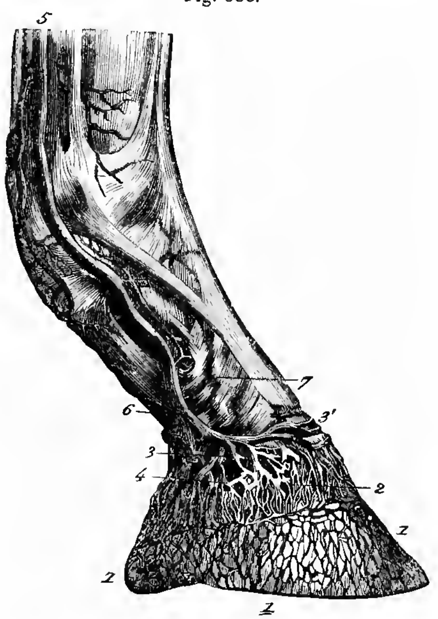
tissue. Communicating largely between each other by multiple anastomoses, like the solar plexus, they appear to be completely isolated from the deeper parts, from which it is commonly believed they emanate.

"Tortuous and split up into branches in their course, the podophyllous veins wind in a serpentine manner along the length of the laminæ they cover, very close to each other, and forming narrow elongated meshes. Their confluence is such, that at certain points they appear bound together by their external walls.

"The calibre of these vessels is tolerably uniform throughout the extent of the podophyllous plexus, except towards the posterior parts, where their principal canals empty themselves into the coronary plexus.

"The podophyllous veins are in anastomotic communication, below, with the circumflex vein of the solar plexus, which they concur to form, and above, with the coronary plexus, which is only a continuation of them.

Fig. 388.



THE VEINS OF THE FOOT.

"C. CORONARY VENOUS PLEXUS.—The corouary venous plexus (Fig. 388, 2, 4) is arranged like a ramose garland around the second phalanx to the origin of the third, and on the surface of the cartilaginous apparatus which completes the latter.

"It is supported, like the other venous networks of the digit, by a fibrous texture immediately subjacent to, and continuous with, the corium of the coronary substance, and is juxtaposed, as well as adherent, to the expansion of the extensor tendon, the lateral cartilages, and to the bulbous enlargements of the plantar cushion.

"This plexus proceeds from the intra-osseous, podophyllous, and solar networks. To facilitate its description, we recognize it in three parts: one *central and anterior*, situated between the two cartilaginous plates, and *two lateral*, corresponding to these cartilages.

"CENTRAL PART OF THE CORONARY PLEXUS.—The central part of the coronary plexus (Fig. 388, 2), immediately subjacent to the substance or cushion of that name, constitutes a very close network formed by innumerable venous radicles, which rise in a tortuous manner from, and are continuations of, the podophyllous plexus, until they reach a large anastomotic vein thrown across from one cartilaginous plexus to the other, and into which they open by from ten to twelve principal mouths (Fig. 388, 3').

"These veins of the central part of the corouary plexus gradually increase in calibre, and diminish in number, from the podophyllus plexus, where they take their origin, to their superior and terminating canal, which itself only appears to be the result of their successive anastomoses.

"CARTILAGINOUS PLEXUS, OR LATERAL PARTS OF THE CORONARY PLEXUS.

—The cartilaginous plates serve to support, by their two faces and the canaliculi by which they are traversed, a mass of very close, anastomosing, and converging veins, which, from its situation, may be designated the *cartilaginous plexus*.

"This cartilaginous plexus is formed by two layers of vessels—a *superficial* and *deep*.

"*Superficial cartilaginous layer or plexus.*—The superficial layer (Fig. 388, 3, 4), extended over the external surface of the cartilaginous plates and bulbs, has its origin by innumerable radicles from the veins of that part of the podophyllous plexus corresponding to the superficies it occupies. These roots, massed in a very dense network, converge towards the superior portions by diminishing in number and augmenting in volume, and terminate in forming themselves, by the aid of successive anastomoses, into ten or twelve principal branches which again unite into two considerable vessels (Fig. 388, 6), situated at the superior limit of the plexus. These vessels, finally, by their last fusion at the inferior extremity of the first phalanx, constitute the digital vein, the satellite of the artery of the same name (Fig. 388, 5).

"Considered from below upwards, in a foot previously prepared by injection, the digital vein, divided into two branches, subdivides itself into secondary branches and ramuscules which diverge and spread over the convex surface of the cartilage and coronary cushion, resembling somewhat the disposition of trees trained as espaliers, whose spreading branches are fixed to the walls on which they ramify.

"The two peripheral branches of the superficial cartilaginous plexus establish communications with the opposite cartilaginous plexus, in contracting direct anastomoses with the branches of the plexus which are symmetrical to them.

"The anterior anastomosing canals are double and superposed.

"The most inferior and snperficial is constituted by the large vein (Fig 388, 3′) thrown slantingly across from one plexus to the other in the median plane, and on the external surface of the extensor tendon ; this receives a considerable multitude of venous ramuscles, which emerge from the anterior part of the podophyllous plexus.

"This first *communicating* vein joins the anterior brauches of the cartilaginous plexus.

"The second *communicating* vein, situated three-quarters of an inch above the first, and beneath the tendon, is thrown transversely from one anterior branch of the plexus to the other. They open into each other on each side, at the same point where the first communicating vein enters.

"Sinuous in the whole of its track, sometimes double, and sometimes formed of several confluent veins—as in Fig. 388—this anastomosing canal serves as an outlet for several deep veins.

"The anastomosis between the posterior peripheral branches of the cartilaginous plexus is formed by an irregularly curved and long vein of large calibre, sinuous or broken in its course, but always considerably longer than the distance from the two cartilaginous plates between which it is extended.

"This *posterior communicating* vein acts as a confluent to the canals emerging from the cartilaginous bulbs, and to the posterior part of the solar plexus, which throws into it five or six well-developed afferent veins.

"*Deep cartilaginous layer or plexus.*—The deep layer of the cartilaginous plexus is formed :

"1. By somewhat large ascending branches from the posterior part of the podophyllous and solar plexuses.

"2. By the deep internal venous apparatus of the third phalanx.

"3. By the deep veins arising from the coronary bone and the ligaments and tendons surrounding it.

"The ascending branches of the podophyllous tissue are introduced by the numerous foramina which traverse the base of the cartilaginous plate and the inferior fibrous covering of the plantar cushion ; they follow the canals which continue those foramina in the substance of the cartilage, and reach its internal face, along with the branches proceeding from the intra-osseous venous system and those coming from the tendons and ligaments, forming a fasciculus of five or six thick couverging veins which unite in two large ascending branches. These anastomose with each other before their definitive junction with the two peripheral branches resulting from the superficial cartilaginous plexus, with which they concur in constituting the digital vein."

b. Internal or Intra-osseous Venous Apparatus.

"Girard, junior, and Rigot have denied that the plantar artery had, in the interior of the phalanx, a satellite venous system. These two able anatomists committed an error.

"The disposition of the venous apparatus in the interior of the phalanx is absolutely identical with that of the arterial.

"The satellite radicular venules of the terminal arteries converge, by forming successive anastomoses, towards the semilunar sinus, into which they enter by the anterior interosseous canals, ascending and descending, and by which the emergent arteries from the semilunar anastomosis pass outwards. There they join into a semicircular canal, the satellite of that anastomosis, which is continued backwards by two efferent veins that follow the posterior canals of the semilunar sinus, emerge by the plantar foramina, pass into the fissure of the same name, ascend within the basilar process, lie at the internal face of the cartilagiuous plate, in one of the infractuosities with which it is sculptured, and concur in the formation of the deep layer of the cartilaginous plexus.

"Beside these veins converging towards the cartilaginous plexus, there is a small number of divergent ones which follow the track of the arteries, and pass into the podophyllous plexus through the anterior porosities of the phalanx.

"The dissection of specimens injected by the veins puts this arrangement of the venous apparatus in the interior of the os pedis beyond a doubt.

"But is this internal venous system limited to the group of vessels which are satellites of the arteries, or is it not rather extended over a vaster surface, and may not all the areolæ of the spongy tissue of the bone be considered as a dependency of it ?

"This way of viewing it would seem to be supported by the result of certain injectious, in which the material introduced by the neighbouring veins has filled all the internal spongiolæ of the bony tissue ; though this was probably due to an accident in the operation, and it is presumable that the direct passage of the venous injection into the areolæ of the spongy tissue arose from a rupture in the vascular walls. If the tissue of the phalanx formed a kind of diverticulum for the venous system, as the opinion just given would admit, operations performed on this part during life, when the texture of the bone is deeply involved, ought to be followed by hæmorrhage from the open orifices of these areolæ—a circumstance which does not take place.

"It does not appear, therefore, that there is, in the structure of the third phalanx, any departure from the general plan on which bones are constructed, and we think that its internal venous system is limited to the vessels—very numerous as they are—which accompany the arterial divisions."

Article III.—Posterior Vena Cava (Figs. 349, *v*; 350, *f*; 389).

This vein, the volume of which is not equalled by that of any other vessel in the body, commences at the entrance to the pelvis by two large roots, the *common iliac veins.*

From this point it is directed forward, beneath the bodies of the lumbar vertebræ, soon reaches the superior border of the liver, where it leaves the lumbar region to lodge itself in the fissure on the anterior face of that gland; passing through this, it traverses the foramen dextrum of the diaphragm, and opens into the postero-external part of the right auricle of the heart.

In this course, the posterior vena cava is naturally divided into three portions—a *sublumbar*, *hepatic*, and *thoracic.*

The *sublumbar portion*, placed to the right of the posterior aorta and to the left of the right kidney and supra-renal capsule, is maintained against the common inferior vertebral ligament and the left psoas parvus muscle by the peritoneum and the pancreas. It is related, besides, to the right renal artery, which crosses its face perpendicularly, as well as the corresponding great splanchnic nerve and the nerve divisions of the right renal and lumbo-aortic plexuses.

In its *hepatic portion*, the posterior vena cava is only related to the liver and diaphragm, which form a complete canal around it.

The *thoracic portion* is lodged between the right lung and its internal accessory lobule, and is enveloped by a particular serous fold—a dependency from the right pleura, and which has been already described (p. 543).

Collateral afferents.—Those vessels which, as considerable as they are numerous, open into the posterior vena cava, are, enumerating them from before to behind:

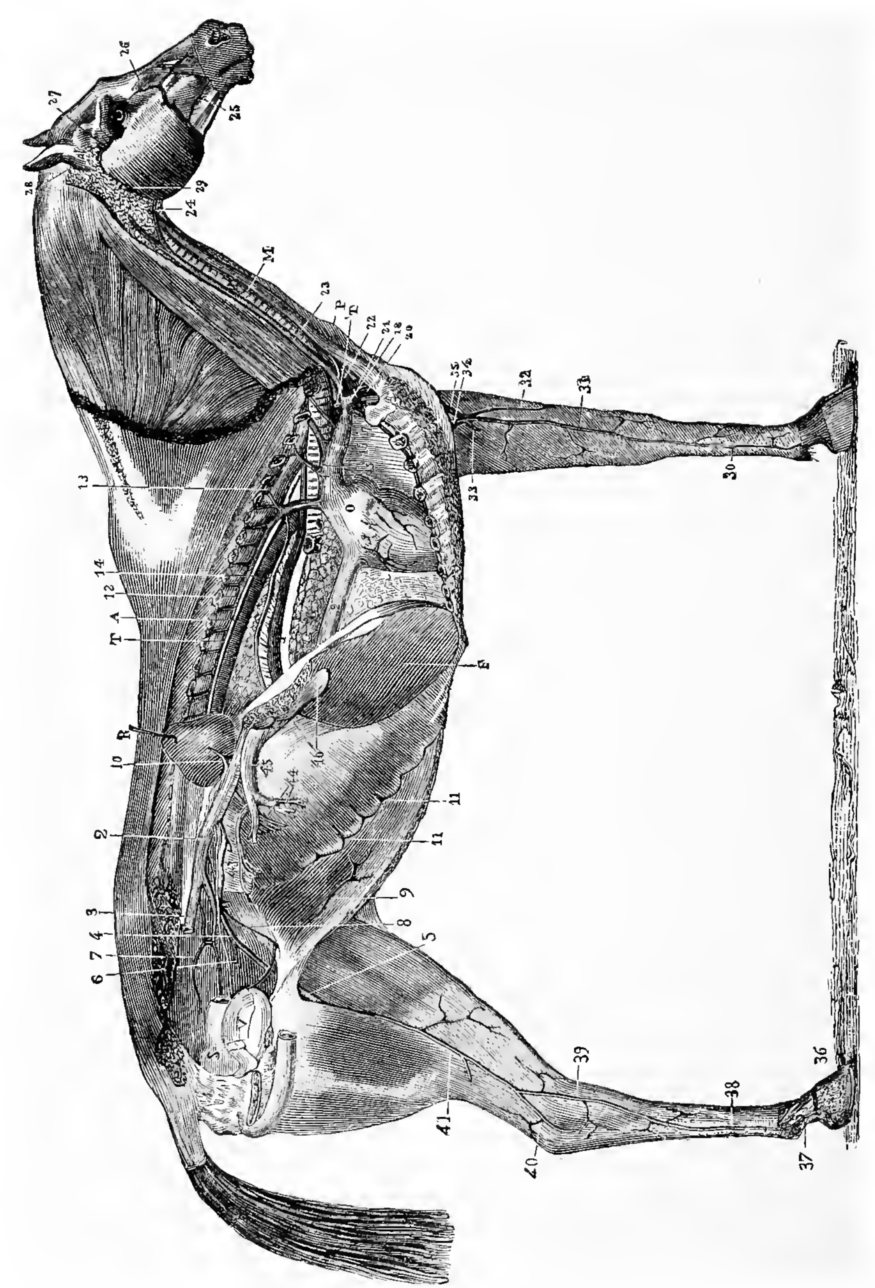
1. The *phrenic* or *diaphragmatic veins.*
2. The *vena portæ*, a trunk into which are collected the majority of the abdominal visceral veins; instead of opening directly into the vena cava, it is divided in the liver like an artery, reconstituting itself into a certain number of thick branches—the *hepatic veins*, which enter the vena cava on its way through the anterior fissure of the liver.
3. *Renal veins.*
4. *Spermatic veins.*
5. *Lumbar veins.*

All these vessels will be studied, in the order above indicated, before the radicles or common iliac veins of the vena cava.

Phrenic or Diaphragmatic Veins.

These are two, sometimes three, enormous vessels lodged in the texture of the tendinous centre, commencing by several branches in the fleshy portion of the muscle, and entering the vena cava as it passes through the diaphragm.

Fig 389.



GENERAL VIEW OF THE VEINS IN THE HORSE.

1, Anterior vena cava; 2, 2, posterior vena cava; 3, right common iliac vein, divided at the ilio-sacral articulation; 4, left common iliac vein; 5, femoral vein; 6, obturator vein; 7, subsacral vein; 8, left spermatic vein; 9, posterior abdominal vein; 10, renal vein; 11, 11, ascending branches of the asternal vein; 12, vena azygos, with its intercostal branches, and in front the subdorsal venous branch, 13; 14, œsophageal vein; 15, dorsal or dorso-muscular vein; 16,

Vena Portæ (Figs. 389, 390).

The manner in which this vessel comports itself gives it an altogether peculiar physiognomy, and has caused it to be considered as a separate vascular system.[1] After what has been already said concerning the structure of the liver, it must be admitted that the vena portæ is distributed in that gland exactly like an artery.

It begins in the sublumbar region, at the anterior mesenteric artery, by the union of three large radicles; it is then directed forwards and a little to the right, traversing the pancreatic ring, below the vena cava, and is afterwards lodged in the great posterior fissure of the liver, where it ramifies by forming the interlobular *veins*, the capillary divisions of which give rise to the sublobular *vessels*.

Interlobular and *sublobular veins* (Fig. 303, VP, V*h*). These vessels having been already studied in the description of the liver, we need not again occupy ourselves with them, but refer only to a peculiarity incompletely noticed in that description, with reference to the sublobular veins.

We know that these vessels are divided into two categories, according to the arrangement of their openings. The majority enter the vena cava in forming a single confluent placed at the anterior extremity of the fissure in the liver, at the phrenic veins; the others open separately over the whole extent of the hepatic portion of the venous trunk. In carefully examining the confluent towards which all the veins of the first group converge, we recognize the junction of three principal veins, one coming from each of the hepatic lobes, and furnished with three very isolated, incomplete valves. With regard to the vessels of the second group, Claude Bernard[2] considers them to come, for the most part, directly from the sublobular veins, and not from the capillary network formed by these veins in the lobules of the liver. It is true that injections readily penetrate from the vena portæ into the vena cava, but they do this quite as much by passing along the large sublobular vessels as the canals of which we now speak; and, besides, if the material forced into the vena portæ is mixed with some imperfectly powdered colouring matter, the injection will arrive colourless, or but slightly tinged, in the sublobular vessels and the vena cava. These facts, we see, do not militate in favour of

[1] Nevertheless, there are communications between the portal system and the general circulation, through the medium of the œsophageal and hæmorrhoidal veins. These communications become very evident when the circulation in the liver is obstructed.

[2] *Leçons de Physiologie Experimentale.* Paris: 1856.

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cervical or cervico-muscular vein; 17, vertebral vein; 18, right axillary vein, cut at the anterior border of the first rib; 19, supra-sternal or internal mammary vein; 20, left axillary artery; 21, termination of the left cephalic vein; 22, left jugular; 23, right jugular; 24, external maxillary or glosso-facial vein; 25, coronary vein; 26, angular vein of the eye; 27, subzygomatic vein; 28, posterior auricular vein; 29, maxillo-muscular vein; 30, internal metacarpal vein; 31, internal subcutaneous vein; 32, radial subcutaneous vein; 33, posterior radial vein; 34, basilic vein; 35, plate or cephalic vein; 36, coronary venus plexus; 37, digital vein; 38, internal metatarsal vein; 39, anterior root of the internal saphena vein; 40, posterior root of ditto; 41, internal saphena; 42, great coronary vein; 43, small mesaraic vein; 44, different branches of the great mesaraic vein; 45, trunk of the vena portæ in its sublumbar portion, lodged in the pancreas; 46, the same in the posterior fissure of the liver—below it is seen entering the substance of the gland. M, Subscapulo-hyoideus muscle cut obliquely in the direction of the trachea; P, cervical panniculus turned down to expose the jugular furrow; O, right auricle of the heart; A, posterior aorta; G, section of the right lung; F, left lobe of the liver behind the section of the diaphragm; R, right kidney carried up and forward; L, œsophagus; V, bladder; S, rectum; T, thoracic duct; T′, termination of that duct in the confluent of the jugulars.

Bernard's opinion; and there is every reason to believe that the system of the vena portæ and that of the vena cava do not communicate, in the adult, otherwise than by the capillary network which is intermediate to the interlobular and sublobular vessels. If any other means of communication exist, they must be extremely small.

(Ligature of the portal vein causes distension of all the abdominal vessels, and a highly congested state of the abdominal viscera; whilst the blood-pressure quickly falls, and the animal dies. So distensible are the abdominal vessels, that they can contain nearly all the blood in the body. The ventricular systole may send a pulse down the valveless posterior vena cava, and cause a pulse in the liver. That gland swells with each systole, and relaxes with each diastole of the heart.)

Constituent vessels of the vena portæ.—The three roots of this vein are the *anterior* and *posterior mesenterics* and the *splenic vein.*

The collateral affluents it receives on its course are principally two: the *right gastro-epiploic* or *gastro-omental veins* and *anterior gastric.*

We will make a rapid survey of all these vessels.

1. Roots of the Vena Portæ.

A. **Anterior Mesenteric or Anterior Mesaraic Vein** (Figs. 389, 44; 390, 2, 7).—This is an enormous venous canal into which flows the blood that has passed through the walls of the small intestine, cæcum, large colon, and the origin of the small colon, the divisions of which correspond exactly to the different branches furnished by the anterior mesenteric artery.

When traced from its opening to its origin, in an inverse direction to the course of the blood, it is observed to lie between the two colic arteries, and proceed beyond the flexure formed by the supra-sternal and diaphragmatic flexures, beyond which it divides into two satellite branches for the colic arteries, which anastomose in arcade towards the pelvic flexure, like the arteries they accompany.

It is therefore by the union of two *colic veins* (Fig. 390, 8, 9) that the anterior mesenteric vein is constituted, and in this formation numerous collateral affluents concur; among these may be noticed the two *cæcal veins* (Fig. 390, 5, 6), the *ilio-cæcal vein* (Fig. 390, 4) coming from the origin of the floating colon, and the *veins of the small intestine*—vessels arranged so exactly like the corresponding arteries, that we may dispense with any further description of them.

B. **Posterior Mesenteric or Posterior Mesaraic Vein** (Figs. 389, 43; 390, 12).—This vessel commences above the rectum, near the anus, by large *hæmorrhoidal* branches which communicate with the homonymous ramuscules of the internal pudic. It is directed forwards, between the two layers of the second mesentery, along the small mesenteric artery, which it passes, and extends to the great mesenteric artery, on the left side of which it unites with the splenic vein, before opening into the anterior mesenteric to form the vena portæ. In its course it receives all the satellite venous branches of the divisions of the artery of the same name, the arrangement of these being similar to that of the arterial ramifications.

C. **Splenic Vein** (Fig. 390, 13).—This is an enormous canal which accompanies the splenic artery, and comports itself exactly like it. It begins by the *left gastro-omental vein* (Fig. 390, 14) anastomosing in arcade with the right gastro-omental, receiving on its track *gastric*, *splenic*, and *omental branches*, and joining the posterior mesenteric after passing above the left extremity of the pancreas, and obtaining the *posterior gastric vein* (Fig. 390, 16).

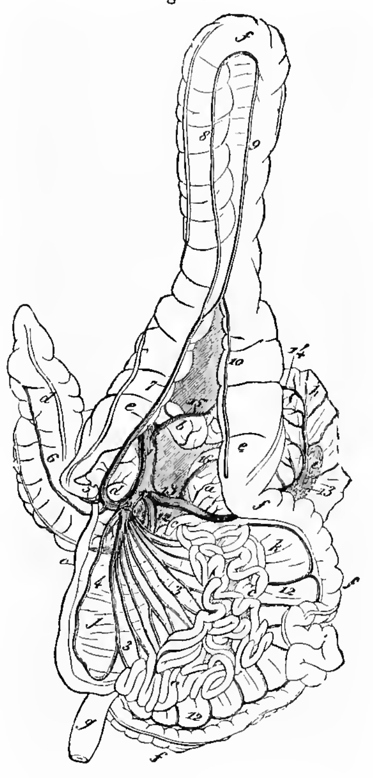
2. COLLATERAL AFFLUENTS OF THE VENA PORTÆ.

A. Right Gastro-omental or Gastro-epiploic Vein (Fig. 390, 15).—We already know that the hepatic artery, before entering the liver, gives off pancreatic branches, a pyloric branch, and a gastro-omental division, which in turn detaches a small duodenal artery; the vessel described as the *right gastro-omental* vein corresponds, in every respect, to all these collateral ramifications of the hepatic artery.

This vein, then, has its origin from around the great curvature of the stomach, but at an undetermined point, as it forms an anastomotic arch with the left gastro-omental vein. Posteriorly, it crosses the dilatation at the origin of the duodenum, receives the *pyloric*, *duodenal*, and *pancreatic veins*, and opens into the vena portæ after traversing the pancreas.

B. Anterior Gastric Vein.—Satellite of the homonymous artery, this vein joins the vena portæ separately, after the entrance of that vessel into the great posterior fissure of the liver, and when very near the terminal extremity of that fissure.[1]

Fig. 390.



THE VENA PORTÆ AND ITS ROOTS (PARTLY THEORETICAL).

1, Trunk of the vena portæ; 2, its origin; 3, veins of the small intestine; 4, ilio-cæcal vein; 5, external cæcal vein; 6, internal cæcal vein; 7, anterior mesenteric vein; 8, 9, colic veins forming the roots of that vessel; 10, collateral vein sometimes continuing the left colic, and joining the anterior mesenteric vein near its origin; 11, common confluent of the posterior mesenteric and splenic veins; 12, posterior mesenteric vein and its collateral branches; 13, splenic vein; 14, left gastro-omental vein; 15, right ditto; 16, posterior gastric vein. *a*, Stomach; *b*, duodenum; *c*, small intestine; *d*, cæcum; *e*, large colon; *f*, floating colon; *g*, rectum; *h*, portion of the great omentum; *i*, spleen; *j*, mesentery; *k*, colic mesentery.

Renal Veins.

Two in number, like the arteries they accompany, these veins are distinguished by their enormous volume and the thinness of their walls. The left, having to cross the abdominal aorta before entering the vena cava, is longer than the right. They receive the majority of the veins from the supra-renal capsules (Fig. 389, 10).

Spermatic Veins.

These vessels correspond to the spermatic arteries in the male, and the utero-ovarian arteries in the female.

[1] Among these collateral affluents of the vena portæ, it is necessary to mention the *biliary veins* which Claude Bernard has injected in the Dog. These vessels, which correspond to the hepatic artery, pass from the posterior surface of the liver, and open into the portal vein at a short distance from that gland.

Testicular vein.—The radicles which constitute this vein present, at their emergence from the superior border of the testicle, a flexiform and very complicated arrangement, enlacing, turning, and inflecting themselves in a thousand ways around the convolutions of the great spermatic artery, and ascending in this manner towards the neck of the abdominal ring, which they pass through, usually after joining to form two trunks. These rise towards the sublumbar region, beneath the peritoneum, in a fold of which they are at first included; they communicate with one another in their course by anastomosing branches, and are generally united into a single spermatic vein, which opens into the vena cava near the renal vein (Fig. 389, 8).

Utero-ovarian vein.—This vein—which is very voluminous—enters the vena cava at the same point as the corresponding vessel in the male, and proceeds, as its name indicates, from the ovaries and uterus by flexuous and reticular branches, the fusion of which into a single trunk only takes place near the vena cava.

Lumbar Veins.

Satellites of the arteries of the same name, these vessels enter the vena cava separately. The most anterior often open into the vena azygos.

Common Iliac Veins.

This appellation is given to two enormous vessels, into which are collected all the veins of the abdominal limb and the posterior part of the trunk—very short vessels, that, by their junction, form the posterior vena cava (Fig. 389, 3, 4).

The common iliac vein is lodged in the angle of separation comprised between the external and internal iliac arteries, and is a continuation of the two satellite veins of these vessels. The right—shorter than the other—passes above the external iliac artery to join the vena cava at its origin. The left—longer—insinuates itself between the body of the second last lumbar vertebra and the terminal extremity of the posterior aorta, to open into the other.

If we trace—as was done with the veins of the anterior extremity—from the ungnal region to the pelvis, all the branches which concur in the formation of these two trunks, we shall find, as the common point of departure for each, a rich *subungual plexus*, from which spring two *digital veins*. To these succeed three *metatarsal veins*, the common origin of all the vessels of the leg. These latter are distinguished as *superficial* and *deep*, and are four in number—two *saphena veins* in the first group, and *two tibial veins* in the second—continued by the *popliteal vein*. This vessel is itself continued by the *femoral* and *external iliac* veins, which finally form the common iliac, by opening into the *internal iliac vein*.

All these vessels will be studied in an inverse order to that in which they have been enumerated, and as follows :—

1. *Internal iliac vein.*
2. *External iliac vein.*
3. *Femoral vein.*
4. *Popliteal vein.*
5. *Deep veins of the leg.*
6. *Superficial veins of the leg.*
7. *Metatarsal veins.*
8. *Veins of the digital region.*

1. Internal Iliac Vein.

This vessel is formed by the satellite veins of the branches furnished by the homonymous artery; these are the *iliaco-femoral*, *obturator*, *iliaco-muscular*, *gluteal*, *lateral sacral*, and *internal pudic*, the distribution of which does not differ from that of the corresponding arterial divisions.

The trunk resulting from the union of these different branches is usually very short; it may even be altogether absent, and we then see the veins which should form it, open into the common iliac vein by forming two or three separate groups, situated very close to each other.

2. External Iliac Vein.

This vein constitutes the principal root of the common iliac, which is but a continuation of it—the internal iliac being only, properly speaking, a collateral affluent of the single canal represented by the external and common iliac veins.

Situated behind the iliac artery, this external iliac vein commences at the anterior border of the pubis, where it is directly continued, without any line of demarcation, by the femoral vein.

The only important vessel it receives on its course is the *iliac circumflex vein*, which, however, opens more frequently into the common than the external iliac.

3. Femoral Vein.

Continuous by its superior extremity with the external iliac vein, and inferiorly with the popliteal, the femoral vein is remarkable for its large volume; it closely follows the artery of the same name throughout its extent (Fig. 389, 5).

The collateral affluents it receives in its course are distinguished by their number and considerable volume. They are:—

1. The *satellite veins of the muscular arteries*.
2. The *internal saphena vein*, which will be again referred to in describing the superficial veins of the leg.
3. The *prepubic vein*, formed by the *posterior abdominal* and the branches of the *internal pudic*. The latter are very numerous and large, and anastomose with each other, forming between the thighs, in the texture of the scrotum and sheath, and above the penis, a very rich network which communicates behind with the cavernous veins. This network only sends a small trunk into the inguinal canal, along the external pudic artery; in its middle part it opens into an enormous branch which passes through the ring in the sartorius muscle, and is lodged in the inferior groove of the pubis to join the femoral vein.

One of these external pudic veins represents the subcutaneous abdominal vein, and communicates with the subcutaneous thoracic vein.

All these branches in the female show an analogous disposition.

4. Popliteal Vein.

Satellite of the popliteal artery, this vein is formed by the union of the anterior and posterior tibial veins.

Among the branches it receives on its course, the *femoro-popliteal vein* may be particularly noted; this accompanies the artery of the same name, and joins the external saphena before opening into the popliteal vein.

5. Deep Veins of the Leg.

These are two in number: the *anterior* and *posterior tibial.*

A. **Anterior Tibial Vein.**—Placed beside the homonymous artery, often double, always very ample, this vein originates on the anterior face of the tarsal articulations by means of several anastomosing roots, the principal of which is formed by the deep metatarsal vein, that passes through the cuboido-cuneo-scaphoid canal from behind to before. After crossing the fibular arch with the artery, it joins the posterior tibial to constitute the popliteal vein.

B. **Posterior Tibial Vein.**—This commences near the hollow of the hock, in front of the calcis, by radicles which principally come from the two saphena veins. It then ascends along its satellite artery, to open into the anterior vein beneath the popliteal muscle.

6. Superficial Veins of the Leg.

These are the *internal* and *external saphena.*

A. **Internal Saphena Vein.**—This vessel shows two roots—an anterior and posterior (Fig. 389, 39, 40).

The first proceeds from the internal metatarsal vein, the second from the external. Both ascend, in converging towards each other, on the internal face of the tibia, uniting into a single branch before reaching the thigh.

This single branch—always very voluminous—glides upwards on the sartorius muscle, and terminates in a variable manner on reaching the groin: sometimes it is insinuated into the interstice between the gracilis and sartorius, to join the femoral vein, and at other times it ascends to the ring of the gracilis, to open into the external pudic veins.

B. **External Saphena Vein.**—It rises, by a short branch, outside the os calcis, communicates, even at its origin, with the posterior root of the internal saphena by means of a large reticular anastomosis thrown transversely in front of the apex of the calcis; and with the posterior tibial, by a large branch that passes between the tibia and the flexor pedis perforans muscle. It follows the external saphena nerve outside the gastrocnemius tendon, behind the external head of the gastrocnemius muscle, and enters the popliteal vein, after joining the femoro-popliteal vessel.

7. Metatarsal Veins.

These veins are three in number, and are distinguished as *internal*, *external*, and *deep;* they proceed from the sesamoidean arch, which is formed by the anastomosis of the two digital veins.

A. **Internal Metatarsal Vein.**—This vessel, the most considerable of the three, appears more particularly to continue the digital vein of the same side. For the greater part of its extent it is placed with the internal plantar nerve, along, and a little in advance of, the flexor tendons. Arriving near the tarsus, it deviates slightly to reach the anterior face of the tarsal articulations, and there communicates—by a very large transverse branch—with the origin of the anterior tibial vein; afterwards it rises on the internal face of the leg, where it constitutes the anterior radicle of the internal saphena vein.

B. **External Metatarsal Vein.**—It occupies, outside the flexor tendons, a position analogous to the preceding. Towards the superior extremity of the metatarsus, it communicates, by a short, thick branch, with the deep vein. It then continues its ascending course by entering the tarsal sheath along with the plantar arteries, and is prolonged in the hollow of the hock, passing along the femoro-popliteal nerve, forming the posterior root of the internal saphena.

C. **Deep Metatarsal Vein.**—This is placed beneath the suspensory ligament, at the inner side of the principal interosseous plantar artery. Near the tarsus, it receives a very large branch from the external vein, and then passes through the cuboido-cuneo-scaphoid canal, to form the largest root of the anterior tibial vein.

8. Veins of the Digital Region.

As these resemble, in every respect, those belonging to the anterior limb, the same description will suffice for both (see p. 698).

Differential Characters in the Veins of the other Animals.

It does not come within our plan to give a complete description of the venous system in these animals, because of the small utility of such a study. To remain faithful to our object, we confine ourselves to the indication of the special characters of the veins on which bleeding is usually practised, and those which may be interesting in a surgical point of view—such as the digital veins of Ruminants.

A. **Angular Vein of the Eye.**—This vessel is remarkable for its large volume in the *Sheep;* and as it is well defined beneath the skin, in consequence of the fineness of that membrane, it is more frequently selected for phlebotomy than in other animals.

B. **Jugular Vein.**—Very large in all animals, and particularly in the *Ox*, this vein deserves the preference given to it when it is proposed to abstract a certain quantity of blood from the system.

In all non-soliped animals there is found an accessory jugular, which sometimes exists in the Horse—but is much less in size—alongside the common carotid artery. It arises from the occipital vein, and therefore extends the whole length of the neck. Sometimes its diameter is small; but it is often so large as to receive a very notable quantity of blood from the principal jugular, when compression is applied to the latter to favour the flow of blood after opening it—a circumstance that explains the difficulty sometimes experienced in obtaining a voluminous jet of blood.

C. **Abdominal Subcutaneous Vein.**—In the Bovine species, this vessel has an enormous volume, especially in the Milch-cow, in contradistinction to the subcutaneous thoracic vein, which is always very small.

This vein is prolonged forward on the wall of the abdomen, to near the xiphoid cartilage, where it passes through to join the internal thoracic vein.[1] Behind, it is formed by multiple branches, which anastomose with each other, or with those of the opposite vein, and are in communication with the proper external pudic veins.

D. **Internal Saphena Vein.**—This is always smaller than in Solipeds, and is rarely selected to extract blood from.

E. **External Saphena Vein.**—This vessel is, on the contrary, more voluminous than in the Horse, and at the same time more superficial; consequently, it is more favourably situated for phlebotomy, as well in *Pigs* and the *Carnivora*, as in *Ruminants*. It arises from the union, in the hollow of the hock, of the two principal roots furnished by the metatarsal veins.

F. **Veins of the Posterior Foot in the Ox.**—As in the Horse, they commence in the *subungual network* of the digital region, which is double, like the region itself.

a. Three *digital veins* leave this reticulum: 1. A *median* or *anterior* one, arising by two roots from the anterior part of each network, passing between the two digits, and joining the anterior superficial metatarsal vein above the fetlock. 2. Two *laterals*, communicating with one another, behind, by a transverse anastomosis which receives several venules from the ungual plexus, and with the anterior vein by an interdigital branch, united by an arch in front of the flexor tendons, above the sesamoid groove.

b. These digital veins are continued by five *metatarsal veins:* two *deep* and one *superficial anterior*, and two *posterior.*

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[1] The openings through which these vessels pass in the abdominal parietes, are commonly named the *milk fountains* or *doors.*

The two *deep anterior veins* are small vessels which accompany the collateral artery of the cannon, which is placed between them. They arise in the interdigital space from the anterior digital vein, communicating, by the inferior metatarsal foramen, with the sesamoid arch, sending off on their way transverse anastomoses, and being continued above the tarsus by the two anterior tibial veins, whose roots they constitute.

The *anterior superficial* vein is very voluminous. It proceeds from the sesamoid arch, receives near its origin the middle digital vein, rises in front of, and a little to the outside of, the tarsus, communicating at this point with the anterior tibial veins; it divides above the tibio-tarsal articulation into two branches: a posterior, forming the anterior root of the external saphena; the other anterior, joining the anterior tibial vein of the external side.

The two *posterior veins* spring from the sesamoid arch. Situated at first between the suspensory ligament of the fetlock and the posterior face of the metatarsus, and communicating there by several anastomoses, these two veins are continued along the tarsus—the one within, the other without. The *internal* follows the corresponding plantar artery, and is prolonged in the tibial region by the posterior tibial and internal saphena veins. The external ascends within the calcis, and is united to a branch of the anterior superficial metatarsal, to form the external saphena vein. Before leaving the deep situation they occupy below the suspensory ligament of the fetlock, these two vessels—but especially the internal—concur to form a perforating branch which traverses the cuboido-scaphoid canal to join the anterior tibial veins.

G. **Veins of the Anterior Foot in the Ox.**—Four *digital veins* escape from the two subungual plexuses: an *anterior*, *posterior*, and two *lateral*.

a. The *anterior digital vein*, which is very slender, is lodged superficially between the two digits, and comports itself at its origin like the analogous vein of the posterior limb, in rising by two roots. In being prolonged above the fetlock, it constitutes a subcutaneous metacarpal branch, which occupies the anterior and internal plane of the cannon, and is united above the knee to the principal cutaneous vein of the forearm.

b. The *posterior digital vein*—often doubled by a small accessory branch—accompanies the common digital artery, and extends along the collateral artery of the cannon, to constitute one of the posterior radial veins.

c. The *internal digital vein*, after passing the digital region, is lodged between the cannon bone and the internal border of the suspensory ligament, proceeds outside the carpal sheath with the radio-palmar artery, and divides above the knee into two branches—an anterior, the origin of the internal subcutaneous vein of the forearm; the other posterior, forming one of the posterior radial veins.

d. The *external digital vein* occupies, on the outer side of the external digit and the cannon bone, a position analogous to the internal vein. It gives rise to several deep metacarpal veins which anastomose, and are mixed with the interosseous palmar arteries; the principal vein and its accessory branches are joined, below the carpus, to the internal vein.

It is to be remarked that these four digital veins communicate, in the interdigital space, by anastomoses resembling those of the posterior limb; and that the last three, or principal veins, anastomose above the fetlock in forming a complicated and variably arranged sesamoid arch, on leaving which these digital veins become metacarpal vessels.

Comparison of the Veins in Man with those of Animals.

In Man, as in animals, the veins are grouped into those of the lesser circulation—or *pulmonary veins*—and those of the greater circulation. The latter open into the heart by three trunks—the *cardiac veins*, and *superior* and *inferior vena cava*.

The *superior vena cava* represents the anterior vena cava of animals, and receives the blood from the veins of the head, thoracic limbs, and a portion of the chest. It extends from the first costal cartilage to the heart, and commences after the junction of the two brachio-cephalic trunks or innominate veins.

The superficial veins of the thoracic limb at first form, on the back of the hand, a plexus of elongated meshes from which the *median*, *radial*, and *ulnar veins* spring. Near the bend of the elbow, the median bifurcates and gives rise to the *median cephalic* and *median basilic*. Blood is abstracted from one or other of these branches. At the arm, all the superficial veins constitute but two trunks—the *cephalic* and *basilic veins*. The deep vessels join these to form the *axillary vein*, which becomes the *subclavian* below the clavicle, then the *brachio-cephalic trunk* (*vena innominata*) when it receives the internal jugular.

The *venous sinuses of the cranial dura mater* are proportionately more developed than in Solipeds, though they have the same arrangement. There is constantly present a middle or inferior longitudinal sinus.

The jugulars, which carry the blood from the cranium and face to the heart, are four in number. The *anterior jugular*—the smallest—descends beneath the superficial cervical aponeurosis, in front of the sterno-mastoideus muscle, and enters the subclavian vein. The *external jugular* commences by the union of the facial and temporal veins; in its disposition it resembles the jugular of the Horse, and would be a complete representative if deprived of the branches from the cranial sinuses. The *internal jugular* arises at the posterior foramen lacerum, at a dilatation of the lateral sinus named the *bulbus venæ jugularis*, and passes to the subclavian vein. Lastly, the *posterior jugular* (or *vertebral vein*) situated beneath the complexus muscle, and in relation with the cervical vertebræ, carries the blood from the spinal sinuses in this region, and which, in Solipeds, is received by the occipital and vertebral veins.

The *inferior vena cava* corresponds to the posterior vena cava of animals, and receives the blood from all the sub-diaphragmatic veins. It originates from the union of the two *common iliac veins*, at the third lumbar articulation, and terminates in the right auricle. In its course it receives the *median sacral*, *lumbar*, *renal*, *supra-renal*, *inferior phrenic*, and *right spermatic veins*. The latter forms on the surface of the testicle, and at the origin of the cord, a rich network—the *spermatic plexus;* on the abdominal portion of the cord it constitutes the *pampiniform plexus*.

The vena cava also receives the *vena portæ*, which has the same disposition as in animals. It begins by three branches—the *great* and *small mesenteric* and *splenic veins*. For affluents, it hss the pancreatic and duodenal venules, and the right gastro-omental vein. It passes behind the pancreas, and not through that gland, as in the Horse.

The veins of the abdominal limb are divided into deep and superficial. The first terminate by forming the *femoral vein*, which, in joining the vessels of the pelvis, constitutes the *common iliac vein*. The *superficial veins* commence by a network on the dorsum of the foot, which gives origin to the two *saphenas—external* and *internal*.

FOURTH SECTION.

THE LYMPHATICS.

CHAPTER I.

General Considerations.

Charged with the absorption and transport of the chyle and lymph, the *lymphatic* or *absorbent vessels* are convergent canals with thin and transparent walls, which originate in the texture of organs by fine reticulated radicles; these, after passing through one or more *glands*—glandiform bodies placed on their course—enter the venous system by two trunks—the *thoracic duct* and the *great lymphatic vein*.

Lymphatic Vessels.

These vessels resemble veins in so many points, as to merit the name of *white-blood veins*. Like these vessels, the lymphatics are directed from the periphery to the centre of the circulatory apparatus; like them, they are nodulated cylindrical tubes; internally, and at those points where they outwardly appear to be constricted, they show numerous valves which look towards the heart. Like the veins, again, they separate into two orders of canals—the ones deep-seated, lodged in the vasculo-nervous intermuscular sheaths; the others superficial, situated on the surface of containing aponeuroses. Like the veins, also, the lymphatics terminate in two principal trunks resembling the venæ cavæ; and, finally, as the veins have three tunics, so have the lymphatics, these not differing in any respect, except in being very much thinner.

If we pass into the domain of physiology, it is also easy to observe characters which are common to the two anatomical systems under comparison. They, in fact, almost equally divide the absorbent function between them—a function which is accomplished in the radicular network of each; and the dynamical process which gives impulsion to the fluids they carry, if it is not quite identical in both, is at any rate very similar in many points.

We may, nevertheless, observe numerous differences between the veins and the lymphatics, and chiefly in their form, number, capacity, and structure.

The *form* of the lymphatic canals is, as we have said, nodulated and cylindrical; but their nodosities are much less marked, and are closer together than in the veins, owing to the larger number and greater development of the valves. Besides, as these vessels proceed for considerable distances, and preserve their regularly cylindrical form with undiminished capacity, if we mentally bring all the divisions of the lymphatic system to a single canal, we no longer have a hollow cone the apex of which corresponds with the heart—although the capacity of the lymphatic vessels augments from the trunk towards the branches; for this canal only represents a series of cylinders joined end to end, and successively decreasing from its origin to its termination.

The *number* of lymphatic vessels in a certain region is always much greater than that of the veins. But as the lymphatics are much smaller than the veins,

Fig. 391.

A LYMPHATIC VESSEL WITH ITS VALVES.

there is not, as might at first be supposed, a proportional increase in their total capacity. Observation, indeed, demonstrates that the relation between the capacity of the lymphatics and the corresponding veins of a region does not exceed one to two.

The *structure* of the lymphatics differs from that of veins, in that there exists, in those of average dimensions, smooth muscular fibres in the adventitious tunic. The presence of muscular fibres in the external tunic of these vessels is rendered necessary by the absence of an impelling organ at the origin of the lymphatic system—such an organ being, in reality, disseminated throughout the extent of the vessels, and aids the *vis a tergo* that causes the lymph to circulate in their interior.

We terminate this short parallel, to notice in detail several points connected with the general history of the lymphatics, and which merit particular attention; we allude to the *origin*, *course*, and *termination* of these vessels.

Origin.—For a long period after the discovery of the lymphatic vessels, a state of profound ignorance existed as to their origin. Nevertheless, the importance of the solution of the problem was well appreciated, as it was really the key to the theory of absorption; numerous hypotheses, therefore, sprang into existence. The anatomists who occupied themselves with the question, were hindered in their investigation by the imperfect means of research at their disposal. Beyond the larger branches, the lymphatics escaped attention, owing to their transparency and tenuity. Thanks, however, to the patient and minute researches of Hunter, Cruikshank, Mascagni, Fohmann, Panizza, Cruveilhier, and Sappey, the lymphatics were injected by colouring matters or by mercury, and thus rendered visible to their finest ramifications.

It is now known that the lymphatics arise from *capillaries*, which form networks or terminal *culs-de-sac*.

These terminal *culs-de-sac* exist in the intestinal villi ; and it is no longer maintained that the ends of these small appendages have an opening by which the lymphatic vessels receive the chyle that bathes the mucous membrane of the intestine.

The *plexuses* are composed of more or less irregular meshes, and their form and volume often vary with the arrangement of the tissues or organs in which they are studied. They may be superficial or deep, and exist together or separately. In many membranes the two networks are found, but then the superficial is thinner than the deep. They are mixed with, or placed above, the blood-vessel plexuses, but never communicate with them.

Do these lymphatic plexuses exist in all the tissues, properly speaking? Here is another question of incontestible importance, the solution of which for a long time occupied the attention of anatomists. Judging by analogies, one is tempted to reply in the affirmative—why, in fact, should the lymphatics not exist everywhere throughout the organism, when the blood-capillaries are constituent parts of the framework of each tissue ? Nevertheless, direct observation has not revealed lymphatic plexuses in all organs ; there are even tissues in which their existence has been absolutely denied—though prematurely, it is well to say, because we may always ascribe the non-success of a lymphatic injection either to the imperfection of the instruments employed, the insufficiency of the measures adopted, or to certain peculiar conditions as yet unknown and attaching to the species of animals selected for the demonstration of the lymphatic networks in a certain region. In support of this last assertion, we may observe that Sappey has not yet been able to inject the pituitary plexuses in Man or the Calf, and that he looks upon their existence as being at least doubtful ; while in the Horse, this lymphatic apparatus is as remarkable for its richness, as for the facility with which it may be filled with mercury.

It may be asserted that they do not exist in the epidermis, or in epithelial layers.

The following are the most trustworthy notions available on this subject.

The lymphatic vessels of the *skin* are very numerous, and form two networks : one, with extremely fine meshes, occupies the most superficial layer of the dermis ; the other, placed beneath the deep face of the integument, includes vessels more voluminous than the first, and communicates with it by multiple ramuscules. These lymphatic plexuses are far from being equally developed in every region, though it is unanimously agreed that no part is entirely destitute of them.

In the *mucous membranes*, an analogous arrangement of these vessels is met with. It is more than probable that they exist throughout the whole extent of these membranes, though their positive demonstration has yet to be made in some regions. In other regions, the injection of these networks is, on the contrary, very easy, and gives the most magnificent results ; we particularly mention the lingual, intestinal, and pituitary mucous membranes. The lymphatics belonging to the latter membrane assume so beautiful an aspect in the Horse, that we would advise anatomists who desire to inject lymphatics always to choose that animal. The operation is simple and always successful, and we are astonished that in the hands of some individuals it should fail. Not only can the two networks of the membrane be filled, but also the trunks arising from them, and which are directed towards the entrance of the nasal cavities, collect in several thick branches around the nostril, and curve up towards the face to reach the submaxillary space, where they enter the glands situated to the right and left of that region.

The majority of anatomists admit the presence of lymphatic plexuses in the *splanchnic* or *synovial serous membranes.* Sappey, however, denies this ; he considers the vessels that can be so easily injected by pricking the external surface of a viscus, as belonging to its proper tissue, and not to the serous membrane covering it. Those on the inner face of the walls of the splanchnic or synovial cavities, and which are sometimes filled with mercury, do not, according to him, come from the serous tunic, but from the subjacent tissues.

The lymphatics do not exist in *vessels.* The *lymphatic sheaths* discovered by His, Robin, and Tomaso, around the blood-capillaries of the Frog, and those of the brain and spleen of Man, and recognized by Rusconi, Milne-Edwards, as well as demonstrated by Ranvier around the vessels of the mesentery, ought not to be considered as the lymphatics of vessels ; they merely surround the ultimate vascular ramifications, and do not arise in the substance of their walls.

In the *nerve tissue* lymphatics have not been discovered, though they are present in the meninges.

Their existence is doubtful in *bone tissue* and in the *muscles ;* but they are abundant in the glands and glandiform organs of the animal economy, forming the finest, richest, and most easily demonstrated plexuses. Sappey admits that they are exceeded by smaller capillary networks and spaces.

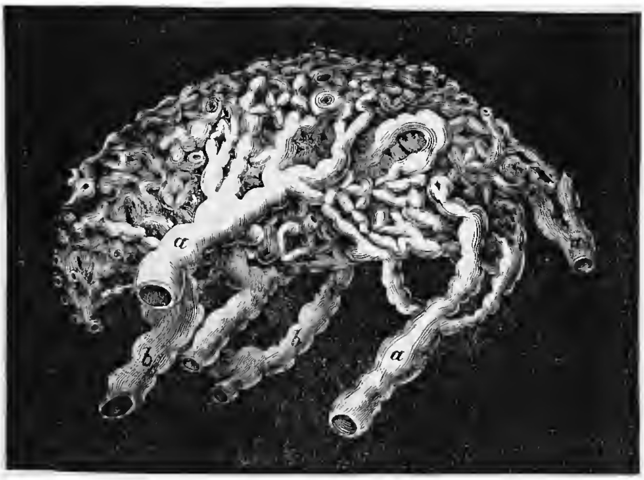
It has been stated above that the lymphatics commence by capillaries arranged in networks. *Are these networks the real, or only the apparent origin of the lymphatics ?* This is a question that has been, and is still, warmly discussed. It is, however, believed that the plexuses are fed by very minute radicles lodged in the substance of the tissues.

But how do these radicles originate ? In the epithelium, says Küss ; in the plasmatic cells of the connective tissue, asserts Virchow ; in the serous membranes, states Recklinghausen, since he observed fatty matters penetrate the lymphatics by the abdominal surface of the diaphragm. The opinion of Virchow is upset at present by the researches of Ranvier, which have modified the descriptions given of the connective tissue. According to this authority, plasmatic cells do not exist in that tissue ; and what have been described as such by Virchow, have been only radiating spaces limited by the fasciculi of connective-tissue fibres, in which elements analogous to lymph corpuscles circulate. The researches of Ranvier tend to support the hypothesis of Recklinghausen, and show that in the connective tissue of the economy there is an infinite number of minute serous cavities into which the lymphatic vessels open, in which the lymph circulates, and which are in communication, on the other hand, with the great splanchnic cavities.

Course of the Lymphatic Vessels.—The lymphatics follow the course of the veins, and are divided, exactly like them, into superficial and deep vessels. The latter, running parallel to each other, are grouped immediately around the corresponding veins, on which they generally lie. The first, although situated in proximity to the superficial veins, are widely spread on each side and on the surface of the superficial aponeuroses, in forming parallel fasciculi, like the deep lymphatics.

The direction followed by the lymphatics in their course, is nearly always somewhat rectilinear; they never show the flexuosities which are so marked in the course of certain arteries, and even some veins. Neither do they communicate with one another by transverse or arching anastomoses, like those so commonly met with in the other two orders of vessels belonging to the circulatory apparatus. They frequently, however, in their parallel course, bifurcate and join the neighbouring vessels. (At certain situations—as at some of the articulations, and in other parts—the larger trunks suddenly break up into a close interlacing plexus of small vessels or capillaries—Fig. 392—which in their arrangement greatly resemble the *rete mirabile* of the blood-vessels. This plexus

Fig. 392.



A SECTION OF A SIMPLE LYMPHATIC RETE MIRABILE, VIEWED FROM THE SURFACE.
a, a, Afferent vessels; *b, b,* efferent vessels only partially visible (from the popliteal space).

is surrounded by condensed connective tissue, and is penetrated by blood-vessels, though no communication takes place between them and these, the only points at which communication occurs being where the great lymphatic trunks empty themselves into the vena cava. This *rete* would appear to be the first step towards the formation of a lymphatic gland.)

But of all the considerations relative to the course of these vessels, the most interesting are those which belong to the glandiform bodies placed along their track, the abridged history of which we shall give immediately.

TERMINATION.—We have already mentioned the thoracic duct and the right great lymphatic vessel as being the receptacles of all the absorbent vessels of the body, and we have also stated that these two trunks enter the general venous system; this union of the blood with the lymphatic system takes place at the origin of the anterior vena cava, and this vessel may be considered as the general confluent for all the absorbents of the body. The researches of Haller, Cruikshank, and Mascagni first threw light on this important fact; and it is to those of Fohmann, Panizza, Rossi, etc., that we owe the realization of this discovery.

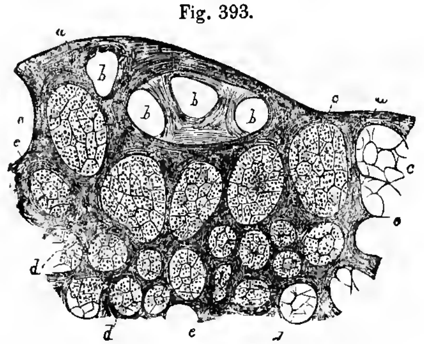
Nerves.—Bert and Laffont have demonstrated the existence of vaso-motor nerves in the chyliferous vessels of the Dog. Galvanization of the solar plexus or the great splanchnic nerve, causes contraction of the wall of these lymphatics. (The lymphatic spaces surrounding vessels are designated *perivascular canals.* Lymphatics originate in lacunæ, or spaces between the fibres of the connective tissues, and these are lined by endothelial cells; they are drained by lymphatic vessels—the arrangement presenting an analogy to the vascular system of insects and crustacea. Masses of protoplasm—the connective-tissue corpuscles—abound in many tissues, occupying some of the interstitial spaces; the latter communicate freely with each other, the communication being tubes in the form of small pores or canals. The fluid drained off is the lymph, which passes into gradually enlarging canals.)

Lymphatic Glands.

The lymphatic glands are ovoid, spherical, or discoid bodies of medium consistency, grey, rosy, or red-coloured, and sometimes quite black, and which at several points intercept the course of the lymphatic vessels.

Their number is considerable, and they are rarely single, but most frequently

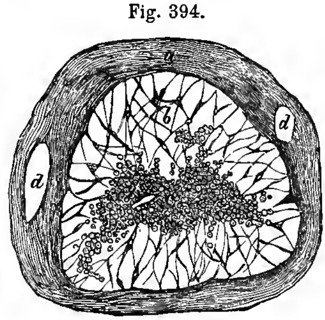
Fig. 393.



SECTION OF A LYMPHATIC GLAND.

a, a, The fibrous tissue that forms its exterior; *b, b,* superficial vasa inferentia; *c, c,* larger alveoli, near the surface; *d, d,* smaller alveoli of the interior, *e, e,* fibrous walls of the alveoli.

Fig. 394.



SIMPLE LYMPHATIC GLAND.

a, The capsule with sections of lymphatics, *d, d,* passing through it; *b,* lacunar and intercommunicating passages, permeated by the lymph, and forming the superficial lymph-path of Frey; *c,* nucleus, or medullary portion, with section of blood-vessel in the centre.

are collected in groups along the blood-vessels. They are always larger in youth than in old age.

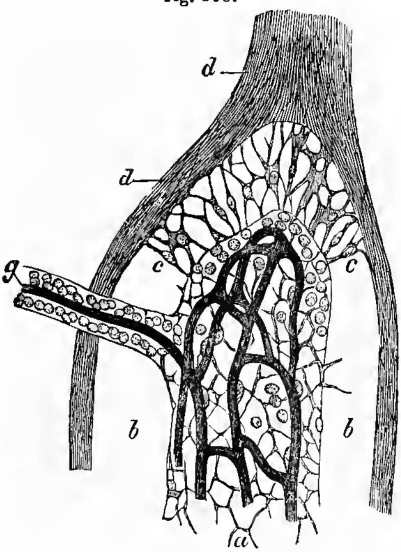
All the vessels of the lymphatic system are provided with at least one gland on their course, and some even pass through two or three before opening into the thoracic duct or great lymphatic trunk. On reaching these glands, they plunge into their substance by ramifications, appearing on the opposite point after being reconstituted into several principal canals, which are generally larger and less numerous than the original vessels. The latter take the name of *afferents* (*vasa inferentia* or *afferentia*); the others are named *efferents* (*vasa efferentia*), because they leave the gland to reach the central canal.

Structure.—The structure of the glands is extremely complex.

They have an *envelope* of connective tissue (continuous with the tunics of the afferent and efferent vessels) that surrounds their proper substance, which is composed of two layers of a different aspect—one *cortical*, the other *medullary*.

The first appears to be granular, the second somewhat fibrous. This proper tissue is sustained by connective laminæ (or *trabeculæ septa*—continuations of the capsule) which contain smooth muscular fibres. The trabeculæ form alveoli in the cortical layer, and a sort of minute tubes in the central layer. These *alveoli*—or *follicles*—are in their turn divided by fine reticular connective tissue into secondary spaces, which become smaller as they lie nearer the centre; at the periphery, where they are most voluminous, they are named *lymph sinuses*. Everywhere these sinuses are filled with lymph corpuscles. The arrangement is identical in the medullary substance; in the interior are seen a great number of arterial capillaries or lymphatic cords. The nerves are derived from the sympathetic system.

Fig. 395.



PORTION OF THE MEDULLARY SUBSTANCE OF THE MESENTERIC GLAND OF AN OX, THE ARTERY OF WHICH IS INJECTED WITH CHROMATE OF LEAD (MAGNIFIED 300 DIAMETERS).

a, Medullary substance with capillary network, fine reticulum of connective tissue, and a few lymph corpuscles; *b, b*, superficial lymph-path, traversed by a reticulum of nucleated cells (*c, c*), with numerous anastomosing prolongations. The lymph corpuscles have for the most part been removed; *d, d*, trabeculæ composed almost exclusively of unstriped muscular tissue; *g*, a small medullary cord, or bridge, containing a blood-vessel and numerous lymph corpuscles.

The *afferent* lymphatics, where they enter the gland, communicate with the alveoli in the cortical substance; these alveoli are connected by the cords of the central layer, and the latter are united, in their turn, to the alveoli of the opposite side of the cortical substance, from which the *efferent* ramuscules spring. The lymph, therefore, traverses every part of the gland, and during this very tortuous course becomes charged with lymph-cells.

Certain glands have a much simpler structure, being entirely composed of lymphatic capillaries rolled up on themselves in clusters, and anastomosing in networks. These capillaries arise from the divergent arborization of the afferent vessels, and are continuous with the convergent branches which, by their union, form the efferent lymphatics. The organs have received the name of *false glands*, though they are really lymphatic glands. In support of this assertion, it may be said that "in descending the animal series, we see the glands becoming more and more simplified, and transformed at a great number of points into an interlacing of vessels. In birds, they only occupy the base of the neck and the entrance to the chest, forming in all the other regions simple plexuses; in reptiles and fishes, the lymphatic glands disappear altogether, and the plexuses that replace them are themselves not at all complicated" (Sappey).

(The cortical part of the gland contains the round masses of adenoid tissue—sometimes called *secondary nodules*—which are continuous with the oval masses, also adenoid tissue, found in the medullary portion; and both oval and round masses are surrounded by the lymph sinuses. In the centre of the meshes of the adenoid tissue is a dark portion filled with cells showing karyokinetic division —this is a *germ centre*, which is more particularly the seat of the formation of leucocytes which pass into the lymph sinuses, and thence into the *vasa efferentia*. The sinuses are lined by a single layer of flat endothelial cells, a similar layer covering the surface of the round masses in the cortex, the strands in the medulla, and the surface of the trabeculæ—these cells being even found in the bands of reticular connective tissue passing from the trabeculæ.

Lymphatic glands are richly supplied with blood-vessels, either entering the hilum or distributed over the surface. Those on the surface ramify on the capsule, and penetrate the gland by running along the centres of the trabeculæ. The large vessel entering the hilum divides into branches, surrounded by connective tissue, and these also run along the trabeculæ. From these minute branches spring, which pass through the lymph sinuses, and are ultimately distributed to the round masses in the cortex and to the strands in the medulla, ending in a very fine-meshed capillary network. The veins pass out of the gland at the hilum. Nerves also penetrate lymphatic glands, and medullated and non-medullated fibres have been traced, but their mode of ending is unknown.

It is important to observe that adenoid tissue containing leucocytes is not limited to lymphatic glands, but is found in many mucous membranes sometimes diffused in a stratum, and sometimes in sharply defined masses; small nodules or follicles are also found in mucous membranes, containing germ centres, and resembling the round masses in a lymphatic gland. These are seen in the solitary and agminated glands of Peyer in the intestinal canal; they vary much in different species of animals, and even in individuals of the same species; and they differ from ordinary lymphatic glands, chiefly in the less intimate connection existing between them and lymphatic vessels. The leucocytes originating in them probably do not enter the lymphatic system directly, but wander through the epithelium covering the surface of the mucous membrane. Amphibia have no lymphatic glands, but, as may be seen in the Frog, there are large lymphatic spaces beneath the skin, which are traversed by very delicate bands of connective tissue.

Preparation of the Lymphatic Vessels.—The lymphatic networks can only be studied after having been filled with mercury by means of injection; but as this operation is not usually practised by the pupils for whom this book is written, the mode of performing it will only be traced in a few words.

The apparatus in use consists of a glass tube continued by a flexible one, which carries at its inferior extremity an iron tap and a fine cannula, also of iron, or (better) glass. To apply this apparatus, the tube ought to be suspended and then filled with mercury; the cannula is then seized by the right hand, keeping it parallel to the membrane we wish to inject, and burying it in the most superficial layer of that membrane. The extremity of the cannula is thus introduced into the midst of the meshes of the lymphatic network, and necessarily wounds some of the capillaries which compose it. In opening the tap, the mercury is allowed to flow into the capillaries by the solutions of continuity they present, and fills them in the most perfect manner. The lymphatic plexuses being always superposed on the capillary blood-vessels, one is always certain of injecting them only, in taking the precaution to penetrate the membrane as superficially as possible. If the point of the cannula enters too deeply, the mercury will pass into the veins, and the operation will be unsuccessful, and must be commenced again.

To study the branches and lymphatic trunks, it will suffice to inflate them from their origin towards their termination. This procedure, properly conducted—and it was almost exclusively the only one adopted by the older anatomists—gives the most satisfactory results, and is even sufficient to demonstrate the texture of the glands. Or the trunks may be filled, from their termination to their origin, by some solidifiable substance.

CHAPTER II.

THE LYMPHATICS IN PARTICULAR.

We will commence with the examination of the *thoracic duct* and all its affluents, and terminate by studying the *great lymphatic vein* (*ductus lymphaticus dexter*).

In this description the glands and principal lymphatic vessels will be only referred to, the arrangement of the networks being already noticed when speaking of the different organs, and they will be further alluded to when treating of the nervous system, the organs of sense, and those of generation.

Article I.—The Thoracic Duct (Fig. 389, t t).

Preparation.—Tie the jugulars and axillary veins near their termination, as well as the anterior vena cava about the middle of its length; expose the thoracic duct by removing the ribs on the right side; open that vessel near the pillars of the diaphragm, and throw into its interior two injections of tallow, one forward, the other backward from the incision. The first injection will fill the canal and the venous reservoir which is intersected between the ligatures applied to the above-named vessels; the second, although directed in opposition to the valves, overcomes the resistance offered by them, and passes into Pecquet's cistern and the principal branches which open into that confluent.

Or we may select one of these branches in the abdominal cavity—for example, one of those which lie beside the colic arteries near their origin—and inject the entire thoracic duct from its origin to its termination. But this proceeding requires more practical ability than the first, in order to find the vessel which is to receive the cannula; if the animal is very fat, it is impossible.

The thoracic duct is the general confluent for all the lymphatics of the body, with the exception of those which come from the right anterior limb and the right moiety of the head, neck, and thorax.

Extent.—It extends beneath the vertebral column, from the first lumbar vertebra to beyond the entrance to the thorax.

Origin.—Its origin is marked by a very irregular dilatation, described as the *sublumbar reservoir*, or *cistern* of Pecquet (*receptaculum* or *cysterna chyli*), into which open the principal affluents of the canal.

This reservoir is divided, internally, by lamellæ into several incomplete compartments, and may be more or less voluminous and circumscribed, as well as very variable in shape.

It is placed above the abdominal aorta and the posterior vena cava, at the anterior mesenteric artery, or more frequently a little behind it.

Course.—To this receptacle succeeds a tube, the calibre of which is very irregular, and appears singularly slender when compared with the diameter of the commencing dilatation, or that of the affluent vessels composing it. This is the thoracic duct. It enters between the two pillars of the diaphragm (*hiatus aorticus*), along with the posterior aorta, deviating more or less to the right side of that vessel, and accompanies it to about the sixth dorsal vertebra, in passing to the outside of the right intercostal arteries, which it crosses, and beneath the vena azygos, beside which it lies. Sometimes, however, we find it carried in this first part of its course directly above the thoracic aorta, between the double series of intercostal arteries, and to the left of the vena azygos, which is then found immediately in contact with the right side of the aorta; or it may even pass to the right of that vein, concealing the greater part of it from sight. Leaving the above-mentioned dorsal vertebra, the thoracic duct abandons the aorta and crosses the flexure of the vena azygos to the left, to extend itself forward on the left, but often also on the right side of the trachea. It afterwards places itself between the two axillary arteries, crosses the interval between the pre-pectoral glands, emerges from the chest, and terminates in a manner to be indicated hereafter.

Termination.—The terminal extremity of the thoracic duct has always a dilatation analogous to that which exists at its origin, though much smaller, better circumscribed, and less irregular—a dilatation which opens into the anterior vena cava sometimes by a single orifice furnished with valves, at other times by two very short branches, the length of which cannot be estimated at more than the fifth part of an inch, and which are also valvular at their entrance. The point where this entrance takes place is nearly always at the summit of the vena cava, and precisely at the point of junction of the two jugulars. The thoracic duct rarely opens elsewhere; though the fact that it does so at times is exemplified in a specimen in the museum of the Lyons School, in which the opening of the duct is placed between the termination of the left jugular and that of the corresponding axillary vein.

Varieties in Solipeds.—"The thoracic duct is far from always showing itself in Solipeds as I have described it, but in its course and insertion it presents a great number of variations which we will now pass in review.

"The single canal is sometimes divided into two branches, which, after proceeding parallel to each other, soon unite to form a single vessel. This division usually takes place at the base of the heart, where the lymphatics of the bronchial and œsophageal glands enter; it forms a ring the diameter of which is often not more than $\frac{2}{5}$ of an inch, or an ellipse whose larger axis is from $\frac{2}{5}$ to $\frac{4}{5}$ of an inch. We see this happen once, twice, and even thrice in the anterior half of the canal, which becomes single at its termination as it was at its origin. The spaces circumscribed by the bifurcations constitute what have been termed the *insulæ*.

"The duct, instead of remaining single, very often becomes double from its commencement (Fig. 397). Then the two canals are sensibly equal, or one is larger than the other. If they are unequal, it is usually the right which has the advantage, though the contrary sometimes occurs. In any case, the two ducts are isolated—one being to the right, the other to the left of the aorta. In advancing towards the entrance to the thorax, they remain completely separated, or communicate with each other by one or two—more or less voluminous, transverse anastomosing branches. Reaching to ten, eight, and sometimes even to two inches from their opening into the jugular gulf, the two ducts approach each other, and become at last a single vessel. Their fusion generally takes place at the base of the heart, and I have never seen them remain distinct throughout their whole extent, to enter the vena cava separately.

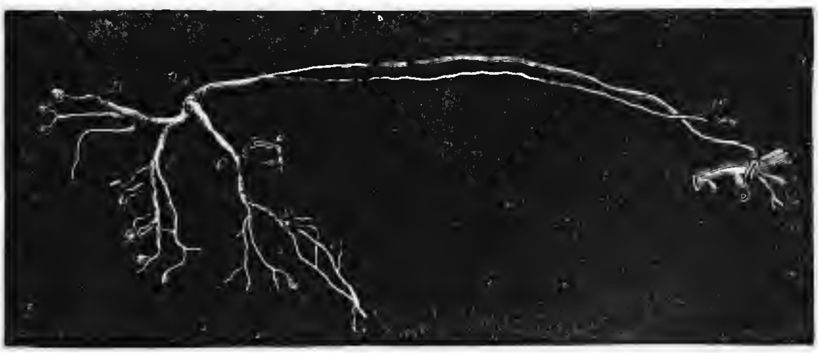
"Sometimes (Fig. 398) there emanates from the gland, at the entrance to the thorax, a long canal which proceeds parallel to the first, and joins it after a retrograde course, near the crura of the diaphragm.

"The thoracic duct, double for the greater part of its extent, from the time it leaves the receptaculum chyli, occasionally ends by becoming triple. In this case, the largest of the two canals is divided into two branches; then the three canals, after pursuing a certain course, all join at the same point, or two are first

Fig. 396.

Fig. 397.

Fig. 398.



DIFFERENT VARIETIES OF THE THORACIC DUCT IN THE HORSE.

A, Receptaculum chyli; B, sublumbar branches; C, anterior mesenteric branch; D, posterior mesenteric branch. In Fig. 396 the duct is single, the usual condition, and enters the summit of the anterior vena cava by two short branches. It is double in Fig. 397; and in Fig. 398 it has a long branch that arises at the entrance to the thorax and joins the duct, by a retrograde course, near the pillars of the diaphragm.

united into a single vessel, into which the third opens at a variable distance from the confluent of the first." [1]

The affluents of the thoracic duct.—The lymphatic vessels which enter the thoracic duct are as remarkable for their number as their volume. Some empty themselves into the receptaculum chyli; a few vessels open into the great lymphatic vessel of the thorax, and the others terminate in that canal near its entrance into the venous system.

The first, variable in their number—particularly the largest—are more especially regarded as the roots of the thoracic duct.

Ordinarily three are found, with a certain number of small accessory trunks. One of the largest branches enters the posterior part of the receptaculum chyli. Very often double, and even multiple, it arises from an enormous group of glands in the sublumbar region, around the posterior extremity of the abdominal aorta and vena cava, and into which are collected all the vessels of the posterior limbs, the pelvis, abdominal walls, and the pelvi-inguinal viscera. The other two trunks reach the left side of the receptaculum, and result from the union of the lymphatics which come from the abdominal digestive organs; among these lymphatics, however, there are some belonging to the parietes of the stomach and the parenchyma of the liver and spleen, and which reach the right side of the receptaculum, to open singly into that cavity.

The affluents the thoracic duct receives on its course, proceed from the viscera contained in the thoracic cavity, and from the walls of that cavity.

Those which terminate at the anterior extremity of the duct are formed by the lymphatics of the left anterior limb, and the left half of the thorax, diaphragm, neck, and head.

We will now examine rapidly all the radicles of these affluents.

Article II.—The Lymphatics which form the Affluents of the Thoracic Duct.

These lymphatic vessels are divided into five groups: 1. Those of the abdominal limb, the pelvis, the abdominal parietes, and the pelvi-inguinal organs. 2. Those of the abdominal digestive viscera. 3. Those of the organs contained in the chest. 4. Those of the thorax. 5. Those of the head, neck, and anterior limb.

Lymphatics of the Abdominal Limb, Pelvis, Abdominal Parietes, and the Pelvi-inguinal Organs.

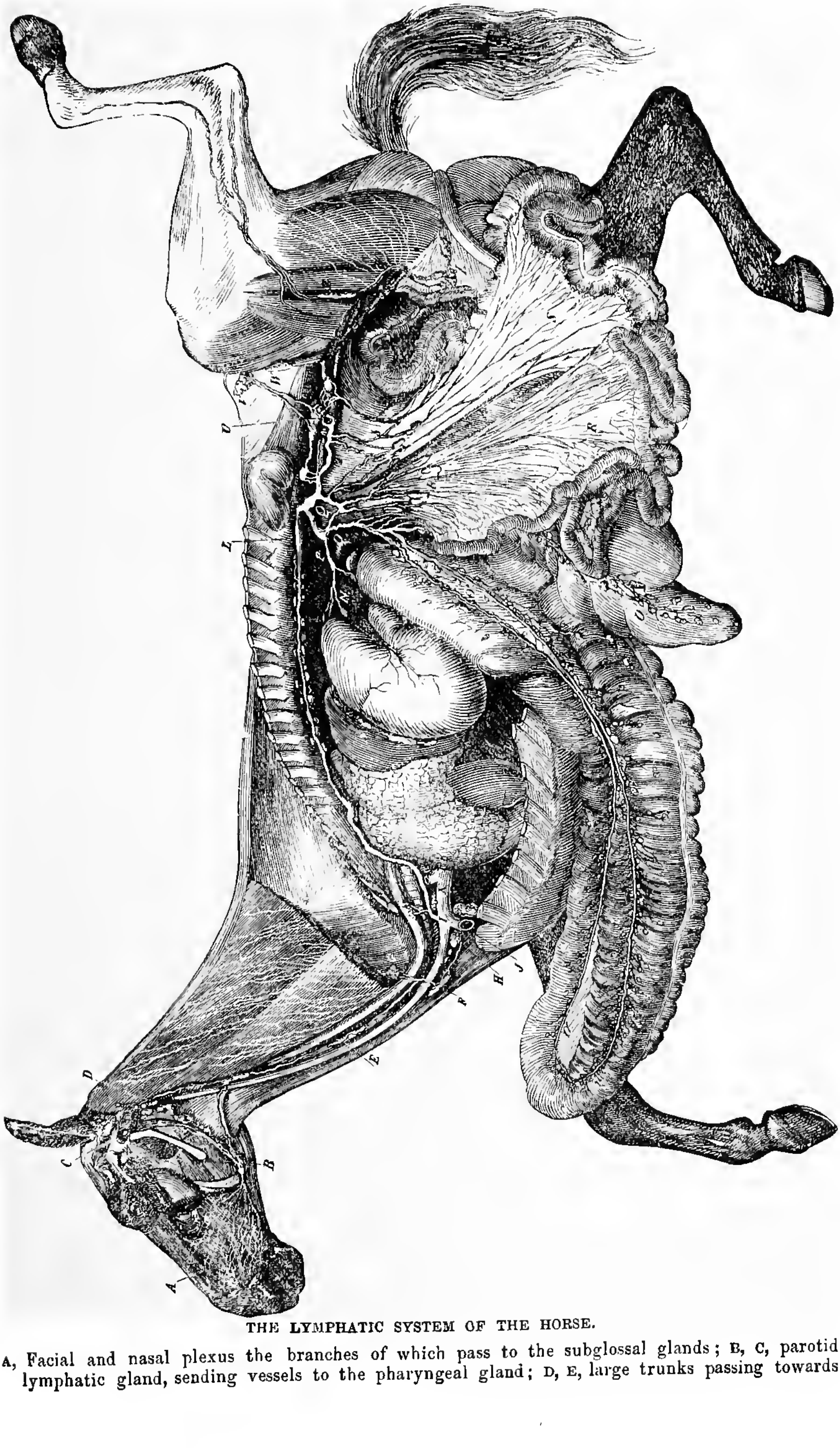
All these vessels converge towards an immense group of glands—the *sublumbar*. Besides these, there are other groups on different parts of their course, constituting the *deep inguinal*, *superficial inguinal*, *popliteal*, *iliac*, and *precrural glands*. The successive description of these glands, and their afferent and efferent vessels, will complete the study of this apparatus.

1. Sublumbar Glands (Fig. 399).

This group, which occupies, as its name indicates, the sublumbar region, comprises: 1. A small single mass situated in the sinus of the angle formed by the two internal iliac arteries, and is often only a single large gland. 2. Another

[1] G. Colin, *Traite de Physiologie Comparée des Animaux Domestiques*, 2nd Edition, vol. ii. Paris; 1871.

Fig. 399.



THE LYMPHATIC SYSTEM OF THE HORSE.

A, Facial and nasal plexus the branches of which pass to the subglossal glands; B, C, parotid lymphatic gland, sending vessels to the pharyngeal gland; D, E, large trunks passing towards mass lodged between the two iliac arteries, and a third placed without, and to the front of, the common iliac ; these two are double. 3. A single agglomeration of glandular lobules dispersed around the origin of the posterior mesenteric and spermatic arteries ; these are separate from one another.

The different masses receive the lymphatics of the pelvis, the emergent branches of the deep inguinal glands, those which come from the iliac glands, some ramuscules from the rectum and large colon, and those from the spermatic cord.

They are bound to each other by communicating branches, and give rise to several series of emergent branches, which soon collect into one or more trunks that enter the receptaculum chyli.

2. Deep Inguinal Glands.

This is a considerable mass of glandular lobules lodged beneath the crural aponeurosis and arch in the interstice between the adductor muscles of the leg, along with the iliac vessels, within which they are placed.

The form of this group is elongated, and its length may be six to eight inches, or even more ; its superior extremity extends as high as the anterior border of the pubis. It is composed of from fifteen to twenty lobules, which rarely have a uniform colour—some being grey and others brown, or nearly black.

The afferents are formed by the superficial lymphatics that accompany the internal saphena vein—the radicles of which may be traced beyond the fetlock—and by the deep satellite vessels of the iliac artery and vein. The efferents proceed to the sublumbar glands, by ascending in the abdomen along the external iliac artery and vein.

3. Superficial Inguinal Glands.

These are placed in front of the inguinal ring, at the side of the sheath, on the track of the subcutaneous abdominal artery, where they form a small elongated mass from two and a half to three inches in length, and are composed of a dozen principal lobules.

Their afferents, which are very numerous, come from the inner aspect of the thighs, the sheath, scrotum, and the inferior abdominal wall. The efferent vessels, much larger, but less numerous—there are only five or six—ascend in the inguinal canal, accompanying the external pudic artery and the inguinal nerves. They enter the deep inguinal glands, after traversing the inguinal canal in company with the prepubic artery.

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the thorax; F, G, H, glands receiving the superficial lymphatics of the neck, a portion of those of the limbs, and those of the pectoral parietes; I, junction of the jugulars; J, axillary veins; K, summit of anterior vena cava; L, thoracic duct; M, lymphatics of spleen—N, of stomach—O, of large colon—S, of small colon; R, lacteals of small intestine—all joining to form the two trunks, P, Q, which open directly into the receptaculum chyli; T, trunk which receives the branches of the sublumbar glands, U, to which the vessels of the internal iliac glands, V, the receptacles of the lymphatics of the abdominal parietes, pass; W, precrural glands receiving the lymphatics of the posterior limb, and which arrive independently in the abdomen; X, superficial inguinal glands into which the lymphatics of the mammæ, external generative organs, some superficial trunks of the posterior limb, etc., pass; Z, deep inguinal glands receiving the superficial lymphatics, Z′, of the posterior limbs.

4. Popliteal Glands.

These are a very small mass of from three to five independent lobules, situated behind the great sciatic nerve and gastrocnemius muscle, between the biceps femoris and semitendinosus muscles, and near the femoro-popliteal artery.

They receive some of the lymphatics from the neighbourhood of the hock, and those coming from the posterior and inferior part of the gluteal region. Their efferents join the deep inguinal glands, by following the muscular interstices of the thigh.

5. Iliac Glands.

Slightly yellow in colour, and of a soft consistence, these glands are five or six in number, and form a group which is situated in the triangular space between the two branches of the circumflex iliac artery. They receive the emergent branches of the precrural glands, and a great number of deep lymphatics from the abdominal wall. Their efferent branches, four or five in number, follow the circumflex iliac artery to pass to the sublumbar glands.

6. Precrural Glands.

Placed within the anterior border of the tensor fascia lata, on the course of the circumflex iliac artery, these glands form a small elongated mass, composed of a dozen lobules lying close to each other. To this group come afferent vessels from the anterior and internal part of the thigh. It gives origin to three or four large efferent vessels, which ascend the internal face of the fascia lata muscle, accompanying the circumflex iliac artery, and entering the abdominal cavity near the angle of the haunch, to join the iliac glands.

Lymphatics of the Abdominal Viscera.

1. Glands and Lymphatic Vessels of the Rectum and Floating Colon.

The glands in this portion of the intestinal tube are: at first, two or three lobules placed at the base of the tail and on each side of the sphincter ani; in the second place, a very numerous series of small glandular bodies situated along the small curvature of the viscus; thirdly, some rounded lobules comprised within the two layers of the mesentery, and placed on the course of the arterial and venous divisions.

Originating in the texture of the mucous and muscular tunics, the lymphatic radicles gain the glands of the small curvature of the colon, and escape from them as efferent branches, which pass in great numbers into the mesentery. These efferents—or at least some of them—pass through the lymphatic glands placed on the course of the blood-vessels, and collect, near the origin of the posterior mesenteric artery, into several somewhat luminous branches, which join the divisions of the sublumbar glands, or those of the large colon.

2. Glands and Lymphatic Vessels of the Double Colon.

There is seen on this enormous viscus a double chain of glands, lying beside the colic arteries, and numerous small lobules disseminated at a short distance from the principal glands, and on the track of the collateral branches furnished by these two vessels.

Received at first, for the most part, by these lobular bodies, the lymphatics which have emanated from the tunics of the double colon afterwards join the principal glands, from which they emerge in forming several large satellite branches for the colic vessels. Only two or three in number at the pelvic flexure, these branches are increased to ten or twelve on arriving near the origin of the colic arteries. It is from the union of these vessels with those of the small intestine, that the two large mesenteric trunks (Fig. 396, A, C) arise, which, with the branches emanating from the sublumbar glands (Fig. 396, B), form the receptaculum chyli.

3. Glands and Lymphatic Vessels of the Cæcum.

There exists, on the track of each cæcal artery, a moniliform series of glands, farther apart from one another than those of the double colic chain, to which the vessels coming from the cæcal membranes are directed, and from which several long satellite branches of the blood-vessels, that proceed to the same trunk as those of the small intestine, depart.

4 Glands and Lymphatic Vessels of the Small Intestine.

The glands which receive the lymphatic vessels from the small intestine are very large and abundant. About thirty in number, of a grey colour, very compact, fusiform, often bifurcated at their superior extremity, these glands are placed in the substance of the mesentery, near the origin of the anterior mesenteric artery, from which those belonging to the portion of intestine nearest the end of the viscus are most distant. The latter also possess, in addition, fifteen special small glandular lobules, dispersed on the track of the ileo-cæcal artery.

We have already noted the richness of the vascular apparatus which rises from the wall of the small intestine, towards the mesenteric glands. It must be added that these glands give off, at their superior extremity, large branches, two or three for each, which soon coalesce to form more voluminous branches, that concur in the formation of the two intestinal roots of the receptaculum chyli.

5. Glands and Lymphatic Vessels of the Stomach.

There are two classes of lymphatic glands for the stomach: 1. Several large glands situated on the small curvature of the organ. 2. A series of small lobules disseminated along the great curvature to the attachment of the gastro-colic omentum.

The vessels which emerge from them "gather on the course of the gastric arteries and veins, and ascend to the great tuberosity, near the trunk of the cœliac artery; there they anastomose with the lymphatics from the spleen and liver, and unite into several flexuous branches, some of which open directly into the thoracic duct, to which the others pass, after joining the anterior trunk of the intestinal lymphatics" (Colin).

6. Glands and Lymphatic Vessels of the Spleen and Liver.

"The lymphatic vessels of the spleen, rising some from the interior of the viscus, others from its surface, pass towards the splenic artery and vein; they traverse several groups of glands on the track of these vessels, commencing from the middle of the fissure, ascend, five or six in number, towards the origin of the artery in forming a sinuous mass, the divisions of which, anastomosing with those of the stomach and liver, open, on the one hand, with the latter in the anterior trunk of the intestinal lymphatics, and, on the other, into a magnificent plexus communicating directly with the thoracic duct.

"Finally, the lymphatics of the liver form a very close network on the surface, and another in the interior of the gland. They collect towards the posterior fissure, and first dip into a primary and very small glandular group, then into a second group of voluminous round glands, which are concealed between the trunk of the vena portæ and the pancreas. They open in common with the vessels of the stomach and spleen" (Colin).

Glands and Lymphatic Vessels of the Organs contained in the Thoracic Cavity.

We find annexed to these organs three groups of lymphatic glands: 1. A series of small granular masses in the posterior mediastinum, on the course of the œsophagus. 2. The *bronchial glands*, situated in the angle of bifurcation of the trachea, around the origin of the bronchi, which they follow for a short distance into the pulmonary tissue. 3. Two long strings of lobules extended on the sides of the inferior face of the trachea, from the base of the heart to near the first rib.

The first group receives the posterior lymphatics of the œsophagus, the second those of the lung, and the third those of the pericardium, heart, and a portion of the trachea and œsophagus. Their efferents, uniting into some large trunks, enter the thoracic duct at different distances.

Glands and Lymphatic Vessels of the Thoracic Walls.

These glands form three series: 1. A double chain of small rounded glands, situated on each side of the dorsal column, above the intercostal spaces, and beneath the costal pleura. 2. A frequently voluminous mass, lodged at the base of the xiphoid cartilage, behind the heart, and in front of the inferior part of the diaphragm. 3. Some rudimentary glands lying beside the internal thoracic vessels.

The lymphatics of the diaphragm, after receiving those from the convex face of the liver, pass to the glands placed at the base of that muscle, whence they escape in the form of several vessels that accompany the internal thoracic vessels, and open into the anterior extremity of the thoracic duct or the great lymphatic vein, the majority of them through the medium of the prepectoral glands. These vessels receive, on their course, those which are brought from the inferior part of the intercostal spaces into the supra-sternal glands.

The other lymphatic vessels of the thoracic wall ascend between the two muscles which close these spaces, and go to the subdorsal glands, which afterwards eject them, near the origin of the thoracic duct, in the form of one or two long vessels proceeding in a retrograde manner on each side of the dorsal vertebræ.

Lymphatic Vessels of the Head, Neck, and Anterior Limb.

These vessels are all directed towards the entrance to the chest, and are gathered into a group of glands, called the *prepectoral*, which, with regard to the lymphatics of the anterior part of the body, play the same part as the sublumbar glands do to the vessels of the posterior region.

Before arriving at this common point of convergence, they are intercepted on their course by other glands, which form four principal groups: 1. The *guttural* or *pharyngeal glands.* 2. The *submaxillary glands.* 3. The *prescapular glands.* 4. The *brachial glands.*

In studying these different glandular groups in succession, with their afferent and efferent vessels, a sufficient idea will be afforded of the entire lymphatic apparatus in the region which remains to be examined.

1. Prepectoral Glands.[1]

These form, on each side of the terminal extremity of the jugular, within the inferior border of the scalenus muscle, a very large mass which extends into the chest by passing beneath the axillary vessels, and ascends to the inner face of the first rib on each side.

Into these glands pass the lymphatic vessels emerging from the prescapular and axillary glands, those which descend along the trachea with the common carotid, and which come from the pharyngeal glands, as well as the majority of those which follow the internal thoracic vessels.

They give rise to several short and voluminous branches: those from the glands of the right side form, by their junction, the great lymphatic vein; and those from the left side join the thoracic duct, or enter separately beside the latter, at the summit of the anterior vena cava.

2. Pharyngeal Glands.

Very numerous, soft, and loosely united to one another, these glands are disposed in an elongated mass that occupies the lateral plane of the pharynx, below the guttural pouch, and is prolonged backwards, even beyond the thyroid body.

They receive all the lymphatics from the head; some come directly from the base of the tongue, the soft palate, the pharyngeal walls, and the larynx; the others are derived from the submaxillary glands, and from a lobule lodged in the substance of the parotid gland.

The efferent branches which leave it are four or five in number. Always voluminous, they descend along the trachea, some separately, but the majority are united in a fasciculus which follows the carotid artery. They have on their course several elongated glands, to which the lymphatic radicles that arise from the cervical portion of the trachea and œsophagus pass. On arriving near the entrance to the chest, they are generally lost in the prepectoral glands; though some of them traverse these without dividing, and directly enter—on the left—the thoracic duct, and on the right, the great lymphatic vein. It has been even possible for us to inject the latter vessel by one of these vessels exposed on the right side.

3. Submaxillary or Subglossal Glands.

They represent a fusiform mass situated at the bottom of the submaxillary space, in the receding angle comprised between the digastricus on the one side,

[1] These are glands, we believe, which ought to be regarded as the representatives of the axillary glands of Man.

and the mylo-hyoideus and subscapulo-hyoideus muscles on the other, above and near to the facial artery. The lymphatics of the tongue, cheeks, lips, nostrils, and nasal cavities join these glands. Their efferents reach the pharyngeal or guttural glands.

4. Prescapular Glands.

By their union these form a kind of chain, at least twelve inches in length, placed on the course of the ascending branch of the inferior cervical artery, beneath the internal face of the mastoido-humeralis muscle, and descending close to the attachment of the sterno-maxillaris muscle.

The majority of the lymphatics of the neck, and those of the breast and shoulder, open into these glands. Their efferents, short and voluminous, enter the prepectoral glands.

5. Brachial Glands.

Situated beneath the anterior limb, inside the arm, these vessels are divided into two groups—one placed near the ulnar articulation, within the inferior extremity of the humerus; the other disposed in a discoid mass behind the

Fig. 400.

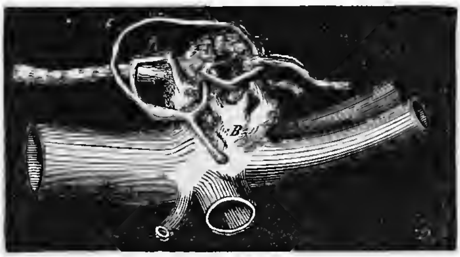


Fig. 401.

THE GREAT LYMPHATIC VEIN AND ENTRANCE OF THE THORACIC DUCT.

A, Thoracic duct; B, great lymphatic vein, or right lymphatic trunk; C, D, anastomoses established between them near their insertion.

brachial vessels, near the common insertion of the teres major and latissimus dorsi.

The first group receives the vessels from the foot and the forearm, which accompany the superficial veins, or pass with the deep arteries and veins into the muscular interstices. It sends nine or ten flexuous branches to the second group, into which open directly the lymphatics of the arm and shoulder, and from which emerge a certain number of efferents that pass, in company with the axillary vessels, to the prepectoral glands.

Article III.—Great Lymphatic Vein.

The second large receptive trunk of the lymphatic vessels, this great vein (the *ductus lymphaticus dexter*) leaves the prepectoral glands of the right side, and therefore becomes the general confluent of the lymphatics from the right anterior limb, the right axillary and superficial costal regions, as well as the right half of the head, neck, and diaphragm.

This trunk is only from three-fourths of an inch to two inches in length.

"It usually opens at the junction of the jugulars, at the side of the vessels, by an orifice furnished with a double semilunar valve. Sometimes one or two of the branches which concur to form it, describe circumvolutions around the corresponding brachial trunks or some of its divisions, before joining the others. Lastly, it is not rare to see this lymphatic trunk anastomose with the thoracic duct by voluminous collateral branches, then unite with it in such a way as to be inserted together by a single orifice above the confluent of the jugulars" (Colin)

Differential Characters in the Lymphatic System of other than Soliped Animals.

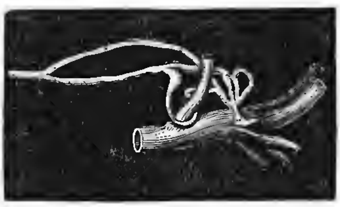
The lymphatic system, glands and vessels, is more developed in Ruminants and the Pig than in the Carnivora.

In this respect the domesticated animals may be classified in the following order: **Ox, Sheep, Horse, Pig, Dog, Cat.**

Ruminants.—"The *thoracic duct* of large Ruminants, when it has entered the thorax by a special opening in the diaphragm, almost distinct from that of the aortic hiatus, is placed above and to the right of the aorta, between it and the spine. There, although outside the corresponding intercostal arteries, it is completely concealed by a thick layer of adipose tissue, in which are numerous subdorsal glands. Towards the fifth dorsal vertebra, it receives a large lymphatic vessel from the enormous gland on the track of the œsophagus in the posterior mediastinum; it then crosses the direction of the aorta and the œsophagus, passes to the left, gains entrance to the thorax, and opens in front of the first rib, above the junction of the left jugular with the anterior vena cava."[1]

"The varieties it presents in the **Ox** are numerous and very common. The rarest disposition is that of a canal, single throughout its entire length, such as it has been described, and such as it is usually found to be in small Ruminants (Fig. 406). This canal (Fig. 403), single at its origin and for the greater part of its extent, often bifurcates towards the base of the heart, or at a short distance from its insertion. Of these two branches, one passes to the right of the œsophagus and trachea, the other to the left of these, in following the ordinary direction; and, at the entrance to the thorax, they either terminate separately, each in the angle formed by the union of the jugular and corresponding axillary vein, or together at the same point—the confluent of the two jugular veins.

Fig. 402.



ENTRANCE OF THE THORACIC DUCT IN THE OX.

"It happens that one of the branches of the bifurcated canal is, in its turn, subdivided into two smaller branches, and that the other experiences at the same time a similar subdivision; so that the trunk of the canal, at first single, becomes double, then quadruple, and consequently opens into the venous system by four distinct orifices. If the branches of the canal, instead of remaining isolated, send off transverse anastomoses, there results a complication of which Solipeds do not offer an example (Fig. 402).

"The thoracic duct is often double throughout its extent. The two canals are then detached separately from the receptaculum chyli; one follows the right side, the other the left side of the aorta, describing an arch with concavity downward at the base of the heart, on the lateral parts of the trachea, terminating either very near one another, and on the same transverse line, at the junction of the two jugulars; or one to the right, the other to the left, in each of these two veins, and not far from their junction with the axillaries (Fig. 404).

"When the two canals arise from the receptaculum, they sometimes repeatedly anastomose with each other by sinuous and curved branches, as shown in Fig. 405.

"Then all the branches collect in the anterior mediastinum, and constitute a single canal

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([1] Zundel has pointed out the curious fact, that in Ruminants, the long, special, lymphatic gland situated between the layers of mediastinum and above the œsophagus, sometimes becomes so voluminous that its weight impedes rumination, especially when the animal is lying. The bolus of food is prevented from ascending into the œsophagus, and this may become a frequent and periodic cause of indigestion.)

which, near its termination, again subdivides into four vessels that open separately, two to the right and two to the left, in the usual place.

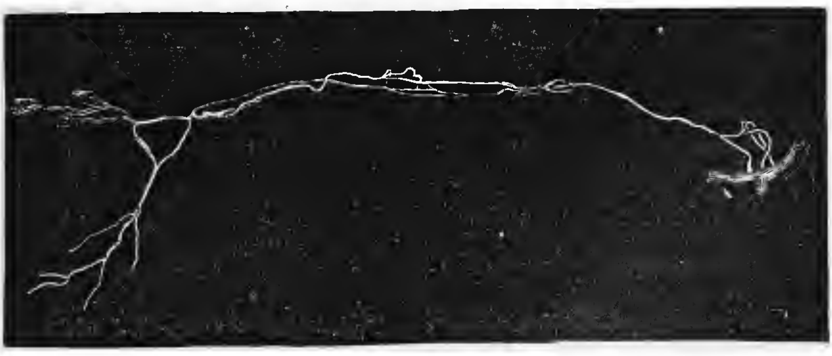
"This variety is the most remarkable and complicated of all those observed in the domesticated animals.

Pig.—"The thoracic duct of the **Pig,** usually single throughout its whole extent, is

Fig. 403.

Fig. 404.

Fig. 405.



VARIETIES IN THE THORACIC DUCT OF THE OX.

sometimes divided, at from 1 to 1½ inches from its entrance, into two branches which soon reunite in an oval dilatation; this, after receiving the vessels from the head, neck, and limbs, opens towards the extremity of the left jugular.

Carnivora.—"In the **Dog,** the receptaculum chyli is enormous; in shape it is ovoid, and is prolonged between the pillars of the diaphragm into the thoracic cavity. The thoracic duct of this animal generally resembles that of the Pig. Yet it sometimes offers in its course and termination very numerous variations; Rudbecky has noticed a bifurcation above the heart, and another bifurcation the branches of which anastomose with each other several times. Swammerdam and Steno have figured numerous irregular anastomotic divisions towards the middle of a single canal, to its point of departure. These old authors have indicated and

Fig. 406.

THORACIC DUCT OF SMALL RUMINANTS.

represented double and triple junctions of different forms. Lastly, Bilsius has shown an arch, or rather a very remarkable ring, at the entrance of the vessel, at its junction with the lymphatic vessels of the neck and anterior limbs, and which is more or less analogous to that which I have observed on several occasions in the Horse, Pig, and Cat."[1]

CHAPTER III.

THE CIRCULATORY APPARATUS OF BIRDS.

We will briefly examine the characteristics of the different portions of the circulatory apparatus—the heart, blood-vessels, and lymphatic vessels—of Birds.

Article I.—The Heart.

The heart, in Birds, is situated quite at the entrance to the chest, in the middle line, and is contained in a *pericardium* that adheres to the posterior diaphragmatic septum and the cervical reservoir. In the domesticated species, it has the form of an acute cone, the base of which is surmounted by a less distinct auricular mass than in the Mammalia.

Internally it has four cavities. The *right ventricle* is more crescent-shaped than in Solipeds, and in a manner envelops the left ventricle in front and to the right; it does not reach th point of the heart. The auricular valve is not tricuspid, and offers a very remarkable arrangement. "This valve, in fact, instead of being formed as usual by membranous curtains, with margin retained by cords fixed to the walls of the ventricles, is composed of a wide muscular leaf which appears to be a portion of the inner wall of the ventricle detached from the interventricular septum. This septum is convex, and the auriculo-ventricular orifice is situated in the space comprised between it and the muscular valve in

[1] G. Colin, *op. cit.*

question; so that when the latter contracts at the systole, it is applied against this septum and closes the passage."[1]

There is nothing particular to note with regard to the *left ventricle*, the walls of which are likewise thicker than those of the right.

The *auricles* have a kind of diverticulum or sinus, where the veins that open into each of these cavities unite.

ARTICLE II.—THE ARTERIES.

The *aorta* of Gallinaceous Birds ascends beneath the lower face of the right lung, then turns abruptly backwards and a little to the left. It attains the middle line towards the anterior extremity of the kidneys, and in this situation it reaches the sacral vertebræ, where it divides into three branches—the arteries of the pelvic limbs, and the middle sacral artery.

Close to its origin, the aorta gives off the *brachio-cephalic* (or *innominate*) *trunks*. With the **Fowl** this name is perfectly correct, as they both furnish vessels to the wings and head. The right passes upwards and forwards, is inflected backwards at the first rib, and continued on the lower face of the wing by the *humeral artery*. It throws off a *thoracic artery*, the volume of which is in relation with that of the pectoral muscles; this artery emits superficial branches that form in the skin of the abdomen, with other vessels, a very rich plexus named by Barkow the *rete mirabile* of incubation. It afterwards gives off a cephalic trunk, from which arise the *ascending cervical*, *vertebral*, and *right carotid artery*. The left brachio-cephalic trunk has the same distribution as the right, a slight difference only being observed in its direction; on leaving the thoracic cavity it describes a small S curvature.

The *carotid arteries* exhibit a somewhat curious arrangement. Each springs from a corresponding brachial trunk; and, placed at first on the sides of the neck, they make a curve, with convexity anterior, and gain the middle line by passing, the right above the œsophagus, the left above the trachea. They remain beside each other, beneath the longus colli, from the second last to the second cervical vertebræ, where they separate at an acute angle and reach the border of the jaw, terminating there in two branches—the *internal* and *external carotid* arteries.

The other collateral branches furnished by it are: 1. The *intercostal arteries*. These may arise from the subcostal branches which are parallel to the aorta; thus, in the **Fowl**, there is a *common descending intercostal* which proceeds from the vertebral, and a *common ascending intercostal* that leaves the aorta as it passes into the abdomen. 2. The *cœliac trunk*, which commences at the middle of the lower face of the lung, and, descending obliquely backward, reaches the posterior aspect of the liver. It divides into several ramuscules, of which there are three principal vessels; a very fine one goes to the spleen; a left or middle one passes to the gizzard along the proventriculus; the third, more voluminous, is directed to the right side, gives a twig to the liver, and is continued by a long *pancreatico-duodenal* branch that joins the extremity of the loop which the intestine forms at its origin. 3. The *anterior* or *superior mesenteric*, which arises at a short distance behind the cœliac trunk, enters the mesentery, and is directed backwards, describing a curve with convexity antero-inferior, and which emits twigs to the intestine. 4. The *spermatic* or *ovarian arteries*. The *inferior* or *posterior mesen-*

[1] Milne-Edwards, *Leçons sur la Physiologie et l'Anatomie Comparee de l'Homme et des Animaux*, vol. iii.

teric leaves the subsacral artery, and, by some ramuscules, reaches the rectum and cloaca.

Shortly before its termination in three branches, the aorta gives off an artery that crosses the middle portion of the kidneys, leaves the abdominal cavity, and becomes distributed to the anterior muscles of the thigh, after detaching the *epigastric artery*. The latter proceeds forward, beneath the skin of the abdomen, and anastomoses with the ramifications of the thoracic artery.

The arteries of the pelvic limbs—the *femoral* or *iliac*, in passing above the kidneys, furnish the *renal arteries;* they then leave the pelvis by the sacro-sciatic foramen, immediately behind the coxo-femoral articulation. Placed beneath the muscles on the posterior face of the thigh, in following the branches of the lumbo-sacral plexus as far as the femoro-tibial articulation, they are then continued by the *popliteal* vessels. These arteries throw off articular ramuscules, the nutrient artery of the tibia, and a long branch to the muscles on the posterior aspect of the leg; they are placed in the groove resulting from the junction of the tibia and fibula, and pass through the osseous interspace to form the *anterior tibial arteries*.

The *middle sacral* continues the aorta to the bottom of the pelvis; when it arrives below the last coccygeal vertebra, it forms a kind of arch, the ramifications of which are distributed among the muscles and quills of the tail.

Article III.—The Veins.

As in Mammals, the veins are distinguished as belonging to the great and lesser circulation.

The veins of the great circulation are collected into three trunks that open into the right auricle of the heart; there are two *anterior venæ cavæ* and one *posterior vena cava*. They enter a particular compartment—a kind of sinus—in the auricle.

The *anterior venæ cavæ* collect the blood from the subclavian arteries and those of the head. The *jugular veins*, which are their principal branches, are not the satellites of the carotid arteries, as in the larger domesticated animals; they are superficial and situated on the sides of the trachea; while the carotids are placed in the middle line, beneath the longus colli. They are not of the same calibre in all species, the right jugular being more voluminous than the left; there is always, however, a transverse anastomosis between the two jugulars, below the base of the cranium.

The *posterior* or *inferior vena cava* commences at the anterior extremity of the kidneys, and passes forwards, traversing the right portion of the liver, receiving the hepatic veins, and enters the right auricle.

Among the branches forming it may be cited the *femoral* or *iliac veins*. These vessels do not accompany the corresponding arteries, and therefore do not enter the pelvic cavity by the sacro-sciatic foramen, but pursue a course analogous to that described for these vessels in Solipeds, in passing beneath the crural arch.

In Birds furnished with a crest and mandibles, the skiu of the head is provided with an excessively rich vascular plexus.

Article IV.—The Lymphatics.

Birds possess *lymphatic vessels* and *glands*. The latter are few, and are scarcely met with elsewhere than in the cervical region; the former are abundant in the viscera, and unite in such a manner as to form *two thoracic ducts*. These ducts commence at the cœliac trunk, and pass along the lower face of the lung, receiving the lymphatics of that organ and those of the wings, and finally open into the jugular veins, a little in front of their union with the axillary veins. A transverse branch forms a communication between the two thoracic ducts, towards their termination.

BOOK VI.

APPARATUS OF INNERVATION.

FIRST SECTION.

THE NERVOUS SYSTEM IN GENERAL.

THE functions of the instruments which we have just described, suffice in themselves to maintain *nutrition*—the locomotory acts which permit the animal to seek its food and to introduce it into its organism, the elaboration and absorption of the assimilable materials of the alimentary mass in the interior of the digestive cavity, the circulation of the reparative fluids in the economy, and the depuration and revivification of these fluids by the action of the lungs and the kidneys; so that nothing more is required to constitute the conditions necessary for the manifestation of the nutritive phenomena.

Besides the apparatus necessary to carry on the functions of nutrition, however, there is needed an excitory system which will move them from their inertia, and a regulating system to direct their special activity. These two systems are found in the *apparatus of innervation.* Stimulated by the nervous system, the properties of the apparatuses of nutrition no longer remain in a latent state, but manifest themselves by their usual results.

Thanks to the nervous system, the animal acquires all the attributes of what it has become habitual, after Bichat, to term *animal life*—that is, sensibility, volition, instinct, and intelligence.

The perceptive centre which receives the stimuli developed at the periphery of organs, or in their substance; the excitatory centre which induces motion in all the other tissues; the seat of the instinctive and intellectual faculties, charged with numerous and important functions—the apparatus of innervation presents itself as a most attractive study. We will commence by giving a general and succinct idea of its conformation, structure, properties, and functions, before undertaking the special description of the different parts composing it.

General Conformation of the Nervous System.

The apparatus of innervation comprises a central and a peripheral portion.

The first represents a very elongated mass lodged in the spinal canal, and expanded at its anterior extremity, which occupies the cranial cavity. This is named the *cerebro-spinal axis* or *centre.*

The second consists of a double series of ramescent branches, which are given off laterally from the central mass, to be distributed to all parts of the body; these branches are the *nerves.*

THE CEREBRO-SPINAL AXIS.—The *axis*, properly so called, lodged in the vertebral canal, forms the *spinal cord.* It is a large white cord, terminating in a point at its posterior extremity, and giving off, at each intervertebral foramen, one of those nerve-branches which, collectively, represent the peripheral portion of the apparatus of innervation.

The expanded extremity enclosed in the cranium is named the *encephalon* (or *brain*). More complicated in its conformation than the spinal cord, this portion is divided, as we shall see, into four parts : 1. A white peduncle, the continuation of the spinal cord. 2. Three grey-coloured ovoid masses, one of which is posterior, the other two being anterior, and placed symmetrically side by side. This medullary prolongation gives off, right and left, like the cord itself, nerve-branches destined almost exclusively to the head.

THE NERVES.—The nerves are in the form of fasciculated cords, issuing from the orifices at the base of the cranium, or through the intervertebral foramina, and passing into all the organs by ramifying like arteries, which they generally accompany.

All the nerves arise from the medullary axis, or from its encephalic prolongation, by radicles more or less apparent. They are divided, according to the relative position of their point of emergence, into two great categories—the *superior*, arising from the corresponding face of the spinal axis ; the others, *inferior*, escaping from the lower face—a distinction which is perfectly appreciable with regard to the cord itself, but which is more difficult to establish in the encephalic peduncle, as it is less distinct.

At their emergence from the bony canals which give them passage, the radicles of each nerve always unite into a thick common trunk.

In the majority of cases, there enter into the composition of this trunk the nerves or fibres of the two orders ; only a few nerves are composed of fibres of the one kind, and these all belong to the brain.

At the origin of the trunk into which the nerve roots are collected, there is a greyish enlargement termed a *ganglion ;* but this peculiarity belongs exclusively to the superior fibres.

After a variable course, which is generally short, this trunk divides into branches, the point of departure for all the nerves of the body. Among these branches, those which are expended in the apparatuses of animal life are pairs, and perfectly alike on both sides of the body. Those of the organs of nutrition are composed at first of an almost symmetrical double chain, placed beneath the spinal column, the elements of which are borrowed from nearly all the nerve trunks issuing from the cerebro-spinal axis ; in proceeding to their destination, their distribution is most irregularly complicated. As they offer on their course a great number of ganglia similar to those we have already mentioned, they are called *ganglionic nerves ;* they are also designated the *nerves of organic* or *vegetative life*, while the others are named the *nerves of animal life* or *of relation.*

Structure of the Nervous System.

Two particular substances—one *grey*, the other *white*—enter into the organization of the nervous apparatus. These two substances are formed, the first of nerve-tubes and united nerve-cells ; the second of tubes alone.

The *nerve-tubes* are microscopic elements, composed of sections or segments about a millimetre in length, joined end to end. Each segment (*interannular segment*) is formed of a sheath (*Schwann's sheath*)—a thin, homogeneous membrane, within which is a layer of protoplasm containing a nucleus. The axis of the segment is occupied by a slender cylindrical stalk (*axis-cylinder of Purkinje*, or *band of Remak*), the space between it and the protoplasm being filled by a viscid opaque substance (*myelin*, *medulla*, *white substance of Schwann*, or *sheath of the marrow*), which is stained black by osmic acid, and is quickly coagulated by cold.

Fig. 407.

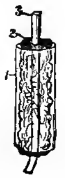


DIAGRAM OF STRUCTURE OF NERVE-FIBRE.

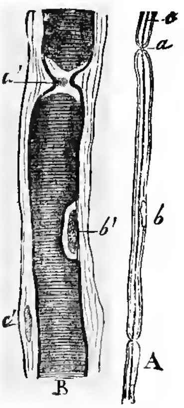
1, Sheath; 2, medullary substance of Schwann; 3, axis-cylinder, or primitive band.

The axis-cylinder is not interrupted at the points of contact of the segments, but passes through the annular constrictions, and runs from beginning to end of the nerve.

When the medulla is solidified, it is seen to be bordered by two dark lines, parallel to the walls of the nerve-tubes; this aspect has caused the latter to be named "double-contoured tubes (or nerve-fibres)."

All the nerve-tubes do not possess, at the same time, these three parts, for the medulla may be absent; so that there are distinguished *medullated* and *non-medullated nerve-fibres*. The first, more or less thick, are met with in the nerve-centres, and at the origin and middle portion of the nerves; the second are found at the termination of nerves, and in the great sympathetic.

Fig. 408.



NERVE-TUBE.

A, Nerve-tube slightly magnified: *a*, annular constriction; *b*, nucleus of the interannular segment; *c*, axis-cylinder. B, Annular constriction and portions of the interannular segments highly magnified (prepared with osmic acid, which colours the myelin black): *a'*, annular constriction, or node of Ranvier; *b'*, nucleus of the interannular segment; *c'*, external nucleus of the sheath.

There are also observed in the nerves of organic life, elongated elements, designated *fibres of Remak*, *grey fibres*, and *nucleated nervous fibres*. These are pale, flattened fibres, with parallel borders, and furnished with elliptical nuclei. Some authorities consider these to be bands of connective tissue, and not nerve elements.

The *nerve-cells*, or *corpuscles*, are voluminous, and formed by a mass of protoplasm without any enveloping membrane, but in the midst of which are numerous fibrillæ. In the ganglia they are covered by a layer of fibrillar connective tissue, provided with nuclei, which appear to furnish them with a very thick enveloping membrane. The nucleus, with one or two nucleoli, is often surrounded by granules of a brown colour.

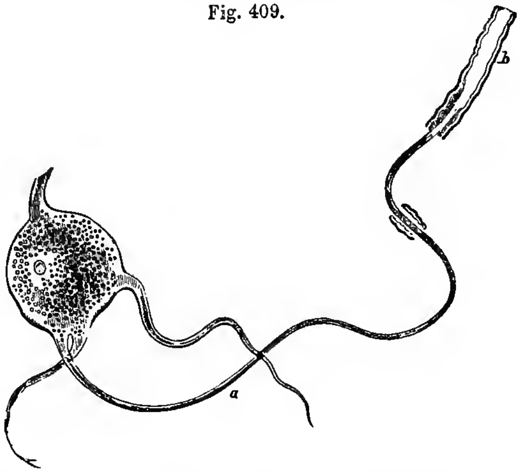
The nerve-cells have prolongations or *poles*, the number of which varies from one to five. Cells with only one prolongation are named *unipolar*; those which have two are *bipolar*; and those which have a greater number are designated *multipolar*. In Mammalia, one of these prolongations—*nerve prolongation*, *prolongation of Deiters*—in the spinal cord establishes relations between a cell and nerve-tube; the others are of a protoplasmic nature, and ramify—these ramifications joining those of neighbouring cells.

Such are the anatomical elements that enter into the structure of the nervous system.

In the white substance of the cerebro-spinal axis, only medullated nerve-tubes of every size are found; in the grey substance are tubes, and a more or less considerable number of nerve-cells are situated along their course.

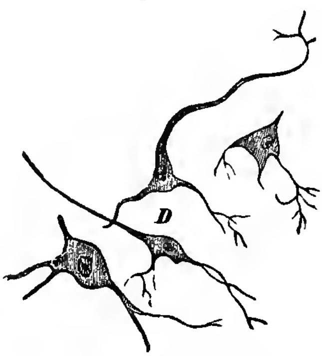
To these two elements is added a large quantity of *blood-vessels*, which are incomparably more abundant in the grey than in the white substance. It must

Fig. 409.



MULTIPOLAR OR STELLATE GANGLIONIC NERVE-CELL, WITH ONE OF ITS PROLONGATIONS—*a*, Becoming continuous with the axis-cylinder of a double-contoured nerve-fibre, *b*.

Fig. 410.



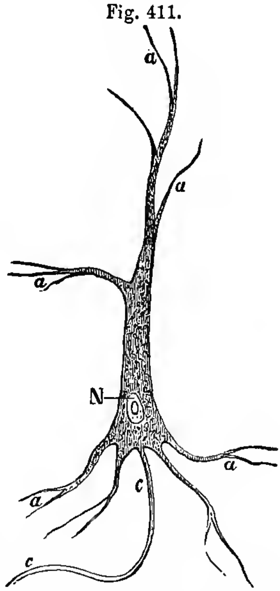
SEVERAL MULTIPOLAR NERVE-CELLS.

be added that in the grey substance the chief elements are these ganglionic cells, supported or bound together by *neuroglia*, distinct from connective tissue.

In the *nerves*, the elementary tubes are alone met with; they are disposed in long bundles, which are collected into successively increasing fasciculi. A cellulo-vascular envelope—the *neurilemma* (or *perineurium*)—binds all these fasciculi into a single cord, and forms a special sheath around each of them. The details of their organization will be referred to hereafter.

It is admitted that the ganglionic nerves, or

Fig. 411.



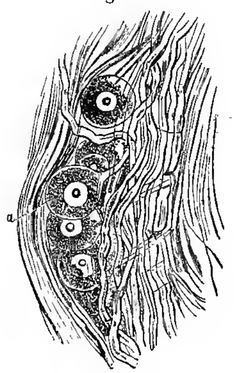
PYRAMIDAL CELL OF THE GREY SUBSTANCE OF THE BRAIN CORTEX.

N, Nucleus; *a*, *a*, small ramified protoplasmic prolongations; *c*, prolongations of the base of Deiters (bringing the cells into communication with the axis-cylinder of the nerve-fibre).

nerves of organic life, possess a greater quantity of slender tubes than the others. These tubes are commonly designated as the *organic nerve-fibres*. They also contain fibres of Remak.

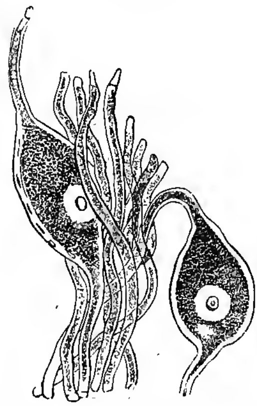
In the *spinal ganglia*, the cells are joined to the nerve-tubes. It has been shown, by dissection and microscopical observation, that the corpuscles composing the ganglia or expansions at the origin of the nerves, are all attached to the superior fibres. The other tubes have none.

Fig. 412.



MICROSCOPIC GANGLION FROM HEART OF FROG.

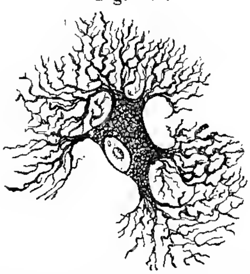
Fig. 413.



BIPOLAR GANGLIONIC CELLS AND NERVE-FIBRES, FROM GANGLION OF FIFTH PAIR IN LAMPREY.

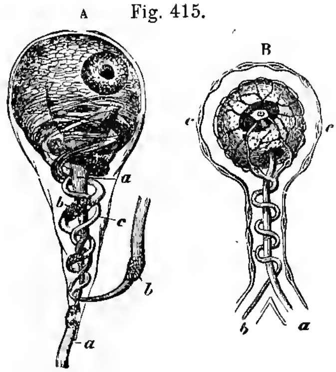
In the *cerebro-spinal axis*, the two substances are equally associated, and connected with each other by a prolongation (or single pole) which is inflected in such a manner as to resemble a T or Y (cells with T-shaped fibres), but in a variable manner, according to the region. In the spinal cord and its prolongations into the encephalon, the grey substance occupies the interior; while it is spread over the exterior of the encephalic lobes, and envelops the white substance.

Fig. 414.



STELLATE NERVE-CELL, FROM THE NUCLEUS CERVICIS CORNU (POSTERIOR VESICULAR COLUMN) OF A FŒTUS OF SIX MONTHS. MAGNIFIED 420 DIAMETERS.

Fig. 415.



STRUCTURE OF GANGLIONIC NERVE-CELL.

A, According to Beale; B, according to Arnold. *a*, Straight fibre; *b*, double spiral fibre; *c*, capsule of connective tissue.

Properties and Functions of the Nervous System.

It would require a long chapter to do justice to this subject, and we could not venture on it here without going beyond our domain. We will, however, offer some remarks on those notions connected with the properties and functions of the nervous system, which are strictly necessary for the comprehension of the anatomical facts to be hereafter dealt with.

And first as to the properties of the nerves.

We will suppose the spinal canal to be opened in the lumbar region, and the cord laid bare in a living animal. If we cut across the inferior roots of one of the spinal nerves, and compress with a pair of forceps one or more of these roots by the end remaining attached to the cord, nothing results to denote that this irritation has had any influence on the organism. But if, instead of operating on the central or attached end of these divided roots, we excite the peripheral end which is continued by the trunk of the nerve, contraction of the muscles of the limb which receives the fibres coming from the irritated roots is produced.

The muscular tissue comports itself as if the irritation were directly applied to it; so that the nerve has served as the medium of communication. It has *received* the stimulus, it has been excited by it, and it has conducted this to the muscles to which the nerve is distributed. This double reaction produced by the nerve-tubes is their special attribute, their essential property. With Vulpian, we might designate it collectively by the term *neurility;* but it is necessary to distinguish the two modes it affects, by naming the property of being impressed by stimuli as the *excitability of the nerve*, and *nervous conductibility* its aptitude to convey the excitations which have impressed it.

The same experiment may be repeated on the upper roots. It is then perceived that the pinching, which produces no effect at the peripheral extremity, causes pain when applied to the central end. The animal testifies immediately, by cries and movements, that it feels the touch of the forceps. But, as will be mentioned in a moment, the impression resulting from this touch has only been perceived by the brain; it has therefore been conducted to the spinal cord by the stimulated nerve-fibres, and then to the brain by the fibres of this medullary axis.

In putting to one side, for the moment, the part played by the latter in the phenomenon now analyzed, it will be seen that the superior fibres of the spinal nerves enjoy the same attributes as the inferior; *neurility* is their appanage, and this property is apparent in its two qualities—*excitability* and *conductibility*. Only here the latter property is exercised in a *centripetal* sense; while in the first instance it acted in a centrifugal sense. But it must not be assumed that these two conductibilities are essentially distinct. The physiological differences by which they appear to be distinguished, seem to belong to the difference in the relations of the nerve-fibres with the organs to which they are distributed. In one case (that of the *centrifugal nerves*), the organs of reaction—the muscles—are placed at the peripheral extremity of the nerves; in the case of the *centripetal nerves*, the organs of reaction—the brain and spinal cord—are found at the central extremity of the nerve-fibres. This theory of the unity of nervous conductibility has, moreover, been proved to be correct by the researches of Philipeaux and Vulpian, who have utilized the experiment of Gluge and Thiernesse on the union of the central end of the lingual (centripetal), with the peripheral end of the hypoglossal nerve (centrifugal); and recently by Bert, in grafting the tail of the Rat into that animal's back.

It is easy to demonstrate that this double property of conduction belongs to all the nerve-fibres arising from the cerebro-spinal axis—*centripetal conductibility* being peculiar to the superior fibres, and *centrifugal conductibility* to the inferior ones. It is also demonstrated that this conduction acts in either one sense or the other, whatever may be the part of the nerves so stimulated; as the nerve-tubes possess, throughout their whole length, the property of excitability and conductibility.

The fibres with centrifugal conductibility are the *motor nerves;* those with centripetal conductibility are the *sensitive nerves.* But sensibility does not exist only in the filaments of the superior roots; it has also been remarked in the lower roots, and these owe it to the filaments which are given off from the roots with centripetal conductibility, and which return to the nervous centres by the motor roots. The sensitiveness evinced by these motor roots is named *recurrent sensibility.* This sensitiveness has also been demonstrated on the peripheral end of the sensory nerves of the limbs and face (Arloing aud Tripier).

The anatomical and physiological characters of the nerves persist as long as they are in communication with the centres. If they are divided at any part of their course, the portion attached to the spinal axis still preserves its properties; but that situated beyond the section—the peripheral end, as it is named—degenerates, and becomes incapable of conducting the sensitive impressions, or of transmitting the voluntary motor stimuli.

Now as to the spinal cord.

Does the medullary axis, which has apparently, in great part, the structure of a nerve, possess, like the latter, *excitability* and *conductibility*—those two essential properties of the peripheral nervous system?

Excitability is entirely absent in the grey substance. On the surface of a section of the cord, the slightest, or even the most intense irritation of this portion, produces no reaction. In the white substance, this excitability can only be easily rendered evident on the surface of the upper bundles or fasciculi, where it is exquisite. With regard to the always limited reactions observed when the stimulations are made on the deep part of the fasciculi, it is difficult to say if they result from the excitability of the spinal cord, or that of the nerve-roots which traverse the white substance.

Nervous conductibility is certainly one of the attributes of the spinal cord; the transmission of stimuli of the sensitive nerves to the brain, and the voluntary movements that result from stimulation of the motor nerves, demonstrate that the necessary medium between the nerves and brain—the spinal cord—possesses conductibility. But the spinal cord may act as a nerve-centre, and the following experiment irrefutably demonstrates it.

I will suppose that an animal has had its spinal cord cut across in the lumbar region, and I excite, by pinching, one of the superior roots remaining intact on the caudal portion. The stimulus cannot be conducted to the brain, as this part is isolated from it; and yet movements take place in the muscles of the posterior limbs. Does it happen that, after section of the medulla, the conductive property of the nerve-fibres which arise superiorly, is interverted and changed into centrifugal conductibility? No; for after the transverse section of these roots, the irritation of their central end produces exactly the same effects. It must be, therefore, that the stimulation had first reached the medulla, and was then transmitted by it to the muscles by means of the centrifugal-current fibres. And this is really what occurred; section of the whole of these fibres of the spinal cord hindered the manifestation of all movement in the muscles, when the superior roots were touched. There is, as has been said, *reflexion* in the substance of the cord, on to the inferior roots, from the irritation due to this pinching; the property which permits the medullary axis to act in this manner is named the *reflex power*. It may be remarked that, if we suppose for a moment the superior and inferior nerve-roots to be united in an arch in the substance of the spinal cord, this reflex property would be nothing more than the nervous conductibility itself operating precisely in the direction special to each kind of nerves.

This union really exists; only the nerve-roots are not in communication, except through the medium of the cells in the grey substance, in which the sensitive is changed into motor excitability.

The reflex power is extinct immediately after death occurs in Mammals, but it may last for several hours, or even for a day, in a decapitated animal in which asphyxia has been averted by pulmonary insufflation. The extent of the movements it determines is in relation to the intensity of the stimulus which is the primary cause of it;—merely local when they result from a slight irritation, these movements may take place in all the muscles of the body after powerful stimulation.

Let us now inquire into the attributes of the encephalon.

Excitability has been determined in several points of the medulla oblongata, and in the interior of the cerebellum. Physiologists have long denied it to the surface of the latter, and to the substance of the cerebral hemispheres; but within the last twenty years, Fritsch and Hitzig, Ferrier, Carville and Duret, and others, have demonstrated that several points of the cerebral and cerebellar cortex are excitable by electricity. The brain possesses conductibility, because the grey substance composing it is the receiver of, and the point of departure for, all the excitations. In fine, the encephalic mass should possess neurility like the nerves, but this general property is more or less modified. What more particularly distinguishes the encephalon, is its action as a *sensitivo-motor centre;* in it arrive the stimuli from the sensitive nerves, and there they are felt and considered. In the brain arise the motor excitations which result in *spontaneous voluntary movements.*

In an animal paralyzed by division of the cord at the occipito-atloid articulation, and in which death has been prevented by artificial respiration, observation demonstrates that sensibility and spontaneous motricity are preserved in the head, the nerves of which are in direct communication with the brain. Pinch the upper lip, and the creature testifies by the movements of this part that it feels pain. Pass the finger towards the eye, and the eyelids are twinkled and closed—a proof that the animal sees objects, appreciates the distance which separates it from them, and tries to remove the eye from their contact. More striking still, the animal feels hungry, and endeavours to satisfy this craving by seizing the food within its reach, and masticating and swallowing it. After this demonstration, it is no longer possible to doubt that, if an animal *feels*, it is by the brain, and if it *wills*, it is also by the brain.

But *sensibility* and *volition* do not constitute the only attributes of the brain; for it is the seat of other manifestations not less interesting—those of the *instincts* and *intelligence.*

The brain also contains several special motor and sensory centres, the existence of which modern physiology and pathology have completely established. These centres are situated in or on the surface of different parts of the organ.

To sum up, the nerves possess a single physiological property—*neurility.* This is manifested by *excitability* and by *centripetal conductibility* in the nerves, the roots of which are uppermost, *centrifugal conductibility* in the nerves with inferior roots.

The spinal cord is *inexcitable* in its grey substance, but is *excitable* on the surface of its superior fasciculi, and with difficulty so in the remainder of its white substance. It serves as the *organ of transmission* between the brain and the nerve-roots; and is, in addition, endowed with *reflex power.*

The brain is endowed with a special activity, to which is due *sensibility, motility,* and *volition,* and the manifestations of *instinct* and *intelligence.*

It remains to examine the nature of the influence the nervous system exercises on the other apparatuses, through the properties we know it to possess. But here again we must limit ourselves to principles.

Since Bichat's time, it has been agreed to divide into two great classes those functions which maintain the life proper of the individual—*those of animal life* or *relation,* and *those of organic* or *vegetative life.*

The first, which are exercised with consciousness, comprise the *sensorial functions* and *voluntary movements;* the latter are induced by the impulsion originating in the brain, and transmitted to the muscles by the nerve-fibres with centrifugal conductibility; the former have for their object the appreciation, by the brain, of tactile sensations—of heat, light, taste, and smell, by means, or through the instrumentality, of the nerve-fibres possessed of centripetal conductibility, which transmits to the brain the stimulus developed at their terminations by these diverse physical agents.

The functions of vegetative life—those which are executed unconsciously, we may say, in animals, and which are not the result of physio-chemical forces—are placed under the influence of the reflex power of the spinal cord. For example, the stomach is empty, and its mucous and muscular membranes remain altogether passive—there being no contractions in the first, nor secretion of gastric fluid in the second. Food arrives in its interior, and immediately its activity is developed; the muscular tunic executes movements which produce mixture of the food, and propel it towards the pyloric orifice; while from the surface of the mucous membrane is poured an abundant solvent secretion. This change is due to the stimulus exercised by the alimentary particles on the extremity of the centripetal nerve-fibres, and which has been transmitted by them to the medullary axis, there reflected on the centrifugal fibres, and carried by these to the tunics of the stomach, the special functions of which are thus brought into play.

It is worthy of remark that the properties of the nervous system, which act in so important a manner on the organs of vegetative life, have no direct influence on nutrition itself. Destruction of the nerves in a certain region will certainly derange the nutrition of its tissues, in consequence of the paralysis of the vessels, but it is not destroyed. There is a very large category of organized beings—vegetables, for instance—in which nutrition is very active, and in which there is no nervous system. So that the property which determines the essential phenomena of nutrition is an attribute of living matter.

SECOND SECTION.

THE CENTRAL AXIS OF THE NERVOUS SYSTEM.

THE *cerebro-spinal axis* is resolved, as we have said, into two principal sections—the *spinal cord* and the *brain*. We will study these two portions in succession—the spinal cord first, in order to facilitate description, although that organ only holds the second place, from a physiological point of view. The *protective parts* of these two apparatuses will, however, be examined before we proceed further.

CHAPTER I.

The Enveloping and Protecting Parts of the Cerebro-spinal Axis.

THE cerebro-spinal apparatus is lodged, as has been already mentioned, in a bony case—the *spinal canal*—which is prolonged anteriorly by the *cranial cavity*; but it is protected more immediately by three *envelopes*, which have received the names of *dura mater*, *arachnoid*, and *pia mater*.

THE BONY CASE CONTAINING THE CEREBRO-SPINAL AXIS.

A knowledge of the bones which enter into the formation of this protective case cannot be acquired without also knowing the case itself; so that we dispense with its special study here. We will allude, however, to the succinct terms already employed in describing the *spinal canal*, and in the same spirit of concision will also describe what has hitherto been deferred—the *cranial cavity*.

1. THE SPINAL CANAL.

This canal communicates, anteriorly, with the cavity of the cranium. Very wide at the atlas—to receive the odontoid process, and allow those rotatory movements of the head which prevent the medulla being injured—the spinal canal suddenly contracts at the axis; it expands again at the end of the cervical and commencement of the dorsal region, where the medulla presents a greater volume, and the movements of the spine are very extensive. Towards the middle of the back, the spinal canal has its smallest diameter; but on leaving this portion, and as far as the lumbo-sacral articulation, it widens again; after which it rapidly decreases, and altogether disappears towards the fourth or fifth coccygeal vertebra. The lumbo-sacral dilatation coincides with the expansion the cord shows at this point, and with the enormous volume of the nerves lying beside it.

2. THE CRANIAL CAVITY (Figs. 41, 42).

This is a very irregular, ovoid-shaped box, the walls of which are formed by the frontal, parietal, occipital, ethmoidal, and temporal bones.

It presents for consideration four planes and two extremities.

The *superior plane* offers on the middle line, and towards its superior third, the parietal protuberance, the two lateral crests of which concur with that eminence in dividing the cranial cavity into two compartments: one posterior, destined to contain the cerebellum; the other anterior, incomparably larger, lodging the cerebral hemispheres, and divided by the single rudimentary crest which begins at the falciform process, and joins the crista galli, into two lateral sections—one for each hemisphere. Hereafter we shall see that the folds of the dura mater are attached to this parietal protuberance, and to the ridges detached from it, thus rendering much more perfect the partitioning of the cranial cavity.

On the *lateral planes* there is also noticed the division into a cerebellar and cerebral compartment, due to the lateral crests of the falciform process, which are prolonged obliquely to near the sphenoid bone; the first section is formed by the occipital and the inner face of the petrous bone; the second by the squamous portion of the temporal, the frontal, and the great wing of the sphenoid bone. Both are concave, and marked by digital impressions, as they also are on the superior plane.

The *inferior plane*, very irregular, offers from behind forward: 1. On the middle line, the basilar channel, into which the greater portion of the medulla is received; the pituitary fossa, made deeper by a circular fold of the dura mater, and lodging the gland of that name; the optic fossa, where the chiasma of the optic nerves is situated. 2. On the sides, the foramen lacerum, partly closed by cartilaginous substance, and by the dura mater; the cavernous sinuses and maxillary fissures, outside which is remarked a deep and wide digital impression for the reception of the mastoid or inferior lobe of the brain.

The *posterior extremity* of the cranial cavity shows the occipital foramen, by means of which this cavity communicates with the spinal canal.

The *anterior extremity* offers, in the median plane, the crista galli process, or superior border of the perpendicular plate of the ethmoid bone; on the sides, the two ethmoidal fossæ—deep depressions containing the olfactory lobes, and at the bottom of which is observed the cribriform plate of that bone.

The Envelopes of the Cerebro-spinal Axis.

Preparation.—In order to study the cerebro-spinal axis, the same preparation as for the spinal cord—to be alluded to hereafter—should be followed. When the centres are freed from their bony covering, the membranes may be incised, dissected, and separated from each other—the arrangement of the sub-arachnoid spaces being rendered apparent by insufflation.

The arrangement of the cranial dura mater can be studied by making an antero-posterior section of the cranium beyond the middle line, and a transverse section in front of the internal occipital protuberance. On the first is seen the falx cerebri and pituitary fold, and on the second the tentorium cerebelli.

The three membranes which cover the cerebro-spinal axis, and separate it from the walls of the bony cavity enclosing it, are thus designated. Generally termed *meninges*, and distinguished as *external*, *middle*, and *internal meninge*, these membranes are better known as the *dura mater*, *arachnoid*, and *pia mater*—names which will be employed in our description.

The *dura mater*, or *external meninge*, is a strong fibrous membrane in contact with the walls of the cranium and the spinal canal.

The *arachnoid*, or *middle meninge*, is a tunic of a serous nature, which resolves itself into two layers—an external, applied to the inner face of the dura mater; and an internal, spread, through the medium of the pia mater, over the cerebro-spinal axis, from which it is again separated at a great number of points by a particular fluid, the *sub-arachnoid* (or *liquor cerebro-spinalis*).

The *pia mater*, or *internal meninge*, is the proper envelope of the central nervous mass ; it is cellulo-vascular, closely adherent to the external surface of the mass, attached to the visceral layer of the arachnoid by more or less dense connective tissue, between the meshes of which is the sub-arachnoid fluid.

This arrangement of the cerebro-spinal envelopes permits the cerebro-spinal axis to be assimilated, to a certain extent, to a viscus, and the bony case containing them to a splanchnic cavity, the serous membrane of which—the *arachnoid* —is covered outside its parietal layer by a fibrous expansion—the *dura mater*, and within its visceral layer by a cellulo-vascular tunic—the *pia mater*, or *internal meninge*.

This collective view of the envelopes belonging to the nerve-centres will now be followed by a special description of each, in which their spinal and cranial portions will be successively considered, after glancing at them in a general manner.

1. The Dura Mater.

This is the most external and the strongest of the cerebro-spinal envelopes, and lines the walls of the cerebro-spinal cavity, exactly repeating its shape. It is, therefore, a second protective covering, which is dilated at its anterior extremity into an ovoid cavity that lodges the brain, and terminates in a prolonged point at the coccygeal vertebræ.

It has two faces—an external, in contact with the walls of the cranium ; and an internal, adhering in the most intimate manner to the external layer of the arachnoid.

In several parts of its extent it is traversed by the nerves that proceed from the cerebro-spinal axis, and by the vessels for this portion of the nervous system.

Structure.—The dura mater possesses the texture of all white fibrous membranes. It is composed of parallel longitudinal fasciculi of connective tissue, mixed with some fine elastic fibres. Bourgelat thought they formed two distinct layers—an external and internal ; but nowhere is it possible to demonstrate this. It receives *blood-vessels ;* the arteries are derived—for the spinal portion, from the vertebral, intercostals, lumbar, and lateral sacrals ; for the cranial portion, meningeal ramuscules, such as the ethmoidal branch of the nasal, the spheno-spinous, and tympanic, mastoideal, and cerebro-spinal arteries. *Nerves* have been seen passing to its cranial portion ; these have been divided into anterior, middle, and posterior. The first are furnished by the ethmoidal filament of the nasal nerve ; the second from the Gasserian ganglion ; and the third, by the ophthalmic branch of Willis. The nerves of the spinal portion are very fine and have no myeline ; at first they accompany the vessels, then leave them to be distributed in the middle part of the membrane. The existence of *lymphatic vessels* has not yet been clearly demonstrated.

Spinal Dura Mater (Theca Vertebralis, Dura Mater Spinalis).—This is a very elongated sheath, continuous at the occipital foramen with the cranial dura mater, and terminated behind by an attenuated point lodged in the narrow channel which, in the middle coccygeal vertebræ, represents a trace of the spinal canal. As it is in shape exactly like the latter, its largest diameter is at the atlas, and at the brachial and lumbo-sacral enlargements of the spinal cord. Its capacity depends greatly on the volume of the latter, and in some of its parts it can allow accumulation of the cerebro-spinal fluid ; this is impossible, however, for nearly the whole extent of the cranial region.

The *external face* of the dura mater is very slightly adherent—especially above—to the walls of the spinal canal; and it is even separated from them, at the intervertebral spaces, by a certain quantity of adipose tissue which is never absent, though the animals be ever so emaciated. This face covers, inferiorly, the common superior ligament, and the veins we have described as spinal sinuses.

(It does not form an endosteum for the vertebræ as it does for the cranial bones.)

The *internal face* gives attachment, between each pair of nerves, to the festoons of the dentated membrane, a dependency of the pia mater. It is rendered smooth and polished by the external layer of the arachnoid, to which it is so firmly united that it is needless to attempt their separation. Here the external layer of the arachnoid is reduced to a simple row of cells with flattened nuclei.

On each side, the *substance* of this meninge is completely traversed by a double series of orifices for the passage of the spinal nerves, around which it sends small special sheaths as far as the intervertebral foramina.

Cranial or Encephalic Dura Mater (Dura Mater Cerebralis).—This membrane forms a sac which is exactly moulded by its external face to the cranial parietes, and by its internal face to the surface of the brain. The latter, therefore, completely fills the cavity of the cranium, a circumstance that explains why an accumulation of fluid is impossible in this region.

External surface.—It adheres strongly, by cellulo-vascular bands, to the cranial walls, the undulations on which it follows. This adhesion is not, however, equally marked everywhere, for on the sides of the roof of the cerebral compartment it is least intimate, and it is closest on the middle plane of this roof, on the crista galli, around the parietal protuberance, on its crests, and towards the lateral faces of the cerebellar compartment at the petrous bones, where the membrane is very thin.

This face gives rise to a number of prolonged sheaths, corresponding to the nerves leaving the base of the cranium. The principal are found around the ethmoidal filaments, the optic nerves, and the two thick branches furnished by the Gasserian ganglion.

Internal surface.—The internal surface of the cranial dura mater is covered by the parietal layer of the arachnoid, which is firmly attached to it only in the spinal region. It sends into the cranial cavity three prolongations, which are distinguished as the *falx cerebri* (*falx*, "a sickle"), *tentorium cerebelli* (*tentorium*, "a tent"), and the *pituitary fold.* These processes complete the partitioning of the cranial cavity, isolate the various external bulgings of the encephalic mass, and protect them from the compression they might exercise on each other.

a. The *Falx Cerebri* is a vertical middle layer comprised between the two cerebral hemispheres, and owes its name to its sickle-like form.

Its antero-superior border is adherent and very convex, and corresponds to the crista galli process, as well as to the median ridge on the inner face of the frontal and parietal bones. This border is very thick, and hollowed internally by a prismatic and triangular venous canal—the middle sinus.

Towards its inferior border, which is free and concave, and rests on the corpus callosum, the falciform process is extremely thin, and cribbled like lacework.

The posterior extremity, or base of the falx, rests on the parietal protuberance.

The anterior extremity advances in a curve to near the optic fossa.

In aged animals, there are sometimes found on the faces of the falx cerebri, especially towards its posterior extremity, small yellow granulations, known as the *Pacchionian bodies.* They are little nuclei of connective tissue that arise from the sub-arachnoideal tissue; *meningeal granulations* would be a better designation than that of *glands*, which is sometimes given to them.

b. The *Tentorium Cerebelli* is composed of two lateral layers, which form a transverse partition between the cerebellum and the posterior extremities of the cerebral lobes.

Each layer, coursed internally by one of the transverse sinuses, offers: an adherent convex border, attached to the parieto-temporal crest; a free concave border, turned inwards and a little forwards, remarkable for its thickness and solidity, and, with the second lamina, circumscribing an oval opening through which the medulla oblongata passes; a superior extremity, attached to the parietal protuberance; an inferior extremity, which disappears above the Gasserian ganglion, near the fold that surrounds the pituitary gland.

Of the two faces of these layers, the anterior corresponds to the cerebral lobes, the posterior to the cerebellum.

c. The *supra-sphenoidal* or *pituitary fold*, is a thick, slightly salient, and almost circular pad, channeled internally by the cavernous sinus, and circumscribing the sella Turcica by enveloping the pituitary gland laterally and posteriorly.

2. The Arachnoid Membrane.

The *arachnoid* has the same arrangement as all the splanchnic serous membranes, in being composed of two layers—a *parietal* and a *visceral*, both constituting a perfectly closed sac, outside of which the cerebro-spinal axis is contained. The cavity of this sac is traversed by the roots of nerves, the vessels of the brain and cord, and filaments and cellular layers which pass from the pia mater to the dura mater; around all these its layers form sheaths, by becoming continuous with one another.

Each of these layers exhibits an adherent and a free face. The *adherent face* of the parietal layer is attached, as we have already seen, to the dura mater. That of the visceral layer covers the nervous axis, in spreading itself over the pia mater, but without accompanying it into the convolutions of the central mass; it is beneath this face of the visceral layer that the cerebro-spinal (or *sub-arachnoid*) fluid is confined in spaces which will be studied hereafter. By their *free face*, which is smooth and moist, like that of all serous membranes, the arachnoid layers are in contact with each other.

Structure.—The structure of this membrane resembles that of all others of the same nature. The meshes of elastic fibres are most abundant in the cranial portion. Everywhere the parietal layer is only composed of a single layer of epithelium. The arachnoid has no proper vessels or nerves; those which pass through it only accompany each other.

Spinal Arachnoid Membrane.—The *parietal layer* presents nothing of interest. The *visceral layer* is separated from the spinal cord, throughout its extent, by a somewhat considerable space (the *sub-arachnoid*), in which the sub-arachnoid fluid is collected; this space is greatest posteriorly, around the terminal extremity of the cord and the nerves of the cauda equina.

The adherent face of this membrane is only connected with the external surface of the spinal cord by thin filaments detached from the pia mater.

Cranial or Encephalic Arachnoid.—There is nothing special to note in the *parietal layer.*

If the *visceral layer* be traced from the occipital foramen—where it is continuous with the spinal arachnoid—to the anterior extremity of the cerebral lobes, it is seen to be prolonged inferiorly on the lower face of the medulla oblongata, as far as the pituitary stem, to which it furnishes a covering: the pituitary gland itself is not covered by the arachnoid, except on a portion of the superior or deep face; from the medulla oblongata it is carried forward, and extends on each side of the cerebellum and cerebral lobes. Superiorly, this internal layer spreads over the surface of the cerebellum, and is reflected at the bottom of the fissure between that organ and the cerebral hemispheres, over the posterior extremity of the latter, enveloping them separately by descending into the interlobular fissure as far as the corpus callosum. Reaching the anterior extremity of the cerebrum, it gains the olfactory lobes, is principally prolonged on their supero-posterior face, and doubles around the ganglion of grey substance on their inferior face, to be continued with the parietal layer.

In covering the external surface of the brain, the cranial arachnoid does not adhere everywhere to the nerve substance, but is only slightly connected with it, through the medium of the pia mater, at such salient points as the summits of the cerebral convolutions. Neither does it dip down to enter the sulci existing between these parts, but passes over them, and in this way forms a large number of sub-arachnoid spaces (*epi-cerebral spaces*) analogous to that developed over the whole extent of the spinal cord.

These spaces, which are filled by the sub-arachnoid fluid, differ widely in form and dimensions. In Man, three principal have been described, and these are also found in animals; Magendie has named them the *confluents of the sub-arachnoid fluid.* Of these three confluents, the *anterior* is situated in advance of the chiasma of the optic nerves, between the two cerebral lobes; the *inferior*, the largest, is comprised between the pituitary stem and the pons Varolii to the surface of the peduncles of the cerebrum; while the third, or *posterior confluent*, lies behind the cerebellum, at the calamus scriptorius.

None of these spaces communicate with the internal cavities of the brain, and, consequently, the sub-arachnoid fluid cannot enter them. Magendie has nevertheless described a communication between the posterior confluent and the ventricle of the cerebellum; though the opening he described towards the calamus scriptorius has not been found in the Horse by Renault, and we may affirm, with Lavocat, that it does not exist in the other animals.

The Sub-arachnoid Fluid.—The fluid contained in the sub-arachnoid spaces is slightly yellow or colourless, and perfectly limpid and transparent. Some authorities assert that it is secreted by the visceral layer of the arachnoid, and others by the pia mater. According to the remark made by Cruveilhier, the nerve-centres are immersed in it, like a fœtus in the liquor amnii; and this remark, which is particularly applicable to the spinal cord, gives the key to the use of this fluid, which keeps the organ away from the walls of the spinal canal, deprives it of the greater part of its weight (Foltz), and thus diminishes every kind of injury to which it might be exposed—whether from without (concussion), or within (intermittent afflux of blood)—in a word, the cerebro-spinal fluid constantly maintains an equilibrium in pressure around the central nervous axis.

(This fluid, so necessary for the support and protection of the cord and brain, is alkaline, and contains but a small quantity of albumen; it varies in quantity, according to the relative size of the cerebro-spinal axis and its containing cavity, or with the amount of blood sent to this region. By affording, under all circumstances, an equable pressure on the brain and spinal cord, and the nerves emanating from these, its importance as a hydrostatic agent is greatly enhanced.)

3. The Pia Mater.

The *pia mater*—the proper envelope of the cerebro-spinal axis—is a thin membrane, the framework of which, essentially connective tissue, sustains on its external face a very abundant network of blood-vessels and nerves.

Applied immediately to the surface of the brain and spinal cord, it adheres firmly to that surface and follows all its inequalities—penetrating between the cerebral or cerebellar convolutions, and forming in each intermediate sulcus two layers that lie against each other.

The *external face* of the pia mater, bathed in part of its extent by the sub-arachnoid fluid, adheres to the visceral layer of the arachnoid by means of a more or less dense and close connective tissue. From it arise the cellular coverings that constitute the neurilemma of the nerves. It detaches a multitude of filamentous and lamellar prolongations to the internal face of the dura mater, which traverse the arachnoid cavity in the same manner as the nerves and vessels, by being enveloped, like these, in a sheath furnished by the arachnoid membrane. Always very short, these prolongations resemble the adhesions between the two layers of that membrane.

The *internal face* is attached to the nerve substance by multitudes of arterial and venous radicles or connective filaments, which leave the pia mater to plunge into that substance.

The *vessels* of the pia mater form a very close network, from which are detached branches that reach the medulla oblongata and brain. They are accompanied by *nerve-filaments*, and are surrounded by *perivascular canals*, which are now believed to be *lymphatics*. Certainly, in their interior a colourless fluid circulates, which contains lymph-corpuscles.

Spinal Pia Mater.—Less vascular than the cranial pia mater, with which it is continuous towards the medulla oblongata, this membrane is remarkable for the arrangement of the prolongations that arise from its two faces.

The *internal prolongations* form longitudinal layers at the fissures of the cord, and enter these fissures.

The *external prolongations* attach, as we have said, the pia mater to the external meninge. A very large number are filamentous in form, and are dispersed over the superior and inferior surfaces of the cord. Others constitute, on each side of the organ, a festooned band named the *dentated ligament* (*ligamentum denticulatum* or *dentata*). These ligaments exist throughout the entire length of the spinal cord, between the superior and inferior nerve-roots: their inner border is confounded for its whole length with the pia mater; and their outer margin, cut into festoons, attaches itself to the dura mater by the summit of the angles separating these festoons.

To complete this description of the spinal pia mater, there may be noticed a *posterior* or *coccygeal prolongation* (*filum terminale*)—a very narrow process formed by this membrane at the posterior extremity of the cord, situated in the midst of the cauda equina nerves, and attached to the bottom of the conical *cul-de-sac* at the termination of the dura mater.

(This ligament, or *membrana dentata*, serves to maintain the position of the spinal cord in its hydrostatic bed, and so prevents the nerves proceeding from it being dragged during flexion of the spine.)

Cranial or **Encephalic Pia Mater.**—The vascular element predominates in this portion of the internal meninge.

This membrane sends scarcely any prolongations to the dura mater, except at the medulla oblongata, though it projects remarkably large ones into the cerebral mass and the sides of the cerebellum. The description of the *velum interpositum*, and the *cerebral* and *cerebellar plexus choroides*, belongs to the brain.

(The pia mater is extremely vascular on the surface of the cerebrum, and forms remarkable anastomosing loops in the intermediate spaces of the convolutions, which chiefly supply the grey substance. It is the nutrient membrane of the brain and spinal cord. Its nerves accompany its arterial branches, and are minute filaments from the sympathetic.)

Differential Characters in the Enveloping and Protective Parts of the Cerebro-spinal Axis in the Other Animals.

The bony space that protects the spinal cord and brain does not present any noteworthy differences in the domesticated animals, and the subject has been already sufficiently studied in the osteology of the head and vertebral column.

With regard to the meninges, their number and general disposition are nearly the same in all the species. In the **Sheep**, however, the cranial dura mater appears to be absent, or is only represented by a mere thickening in which is the middle sinus; the falx cerebri is only indicated towards its two extremities. The vestige of this septum is more developed in the **Goat.**

Comparison of the Enveloping and Protective Parts of the Cerebro-Spinal Axis of Man with those of Animals.

There is nothing particular to be said respecting the cranial cavity and spinal canal, nor yet the arachnoid and pia mater. The dura mater has the folds described in Solipeds, and, in addition, a *falx cerebelli*, that extends from the tentorium of the same name to near the foramen magnum. The meningeal granulations, or Pacchionian glands, are nearly constant in aged individuals, and their volume is sometimes so considerable, that by compression they thin away, and even perforate, the cranial bones at corresponding points.

CHAPTER II.

THE SPINAL CORD.

Preparation.—Isolate the cranium and vertebral column from all the other parts of the body; open the spinal canal and the cranial cavity by their superior surface, as in Fig. 416, by raising with a chisel (or *rogne-pied*—the farrier's "toe-knife") and hammer, the roof of the skull and annular portion of all the vertebræ. The organ may then be studied *in situ* in its bony case, and surrounded by its membrane; afterwards extract the whole spinal cord enclosed in the dura mater, and open up the latter along the course of the cord, so as to completely expose that portion of the nervous system.

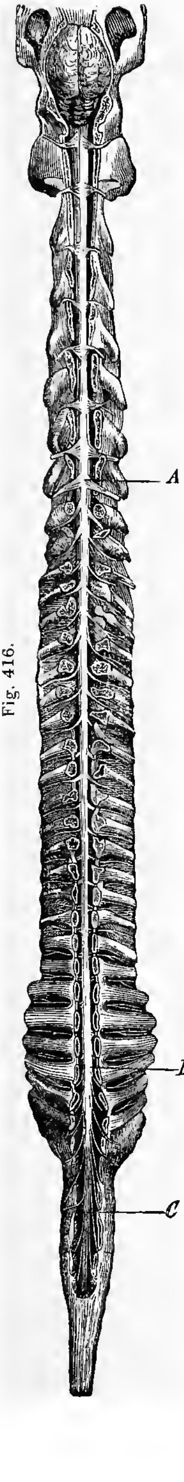
On a cord hardened by water to which a tenth part of nitric acid has been added, the arrangement and distribution of the grey and white matter may be studied; the different cords composing it may be also more or less exactly separated.

(The saw and farrier's pincers, or spine ratchet, will be found useful auxiliaries in the tedious and delicate operation of exposing the brain and cord, and particularly in laying open the cranial cavity. An easy mode of obtaining access to the spinal canal and its contents, is to saw through the laminæ of the vertebræ on each side, at the roots of the transverse processes, and raise the arches with the chisel or toe-knife.)

External Conformation of the Spinal Cord.

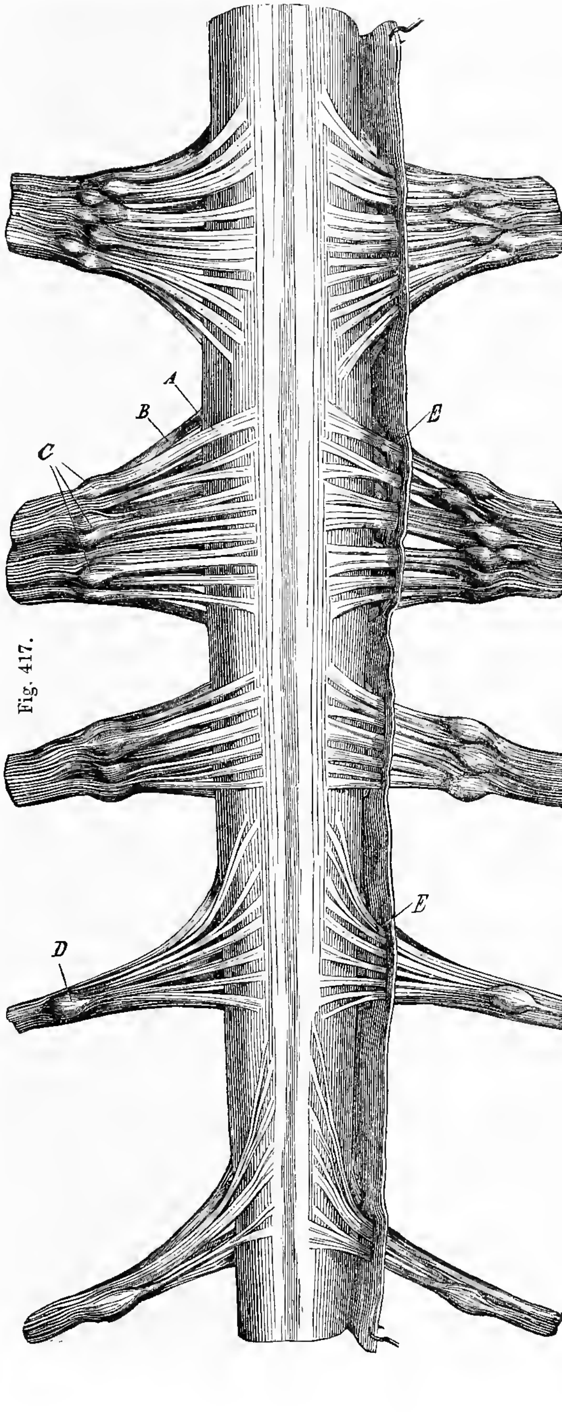
General view.—The *spinal cord* is that portion of the nervous centres which occupies the spinal canal. It is a thick, white, and irregularly cylindrical cord,

Fig. 416.



GENERAL VIEW OF THE SPINAL CORD.—A, Cervical or brachial bulb; B, lumbar bulb; C, cauda equina.

Fig. 417.



SPINAL CORD AT THE CERVICAL BULB, OR BRACHIAL PLEXUS, SHOWING ITS UPPER FACE AND THE ROOTS OF THE SPINAL NERVES.

A, Superior roots; B, inferior roots; C, multiple ganglia of the superior roots; D, single ganglion on an exceptional pair; E, E, upper roots passing through the envelopes.

commencing at the occipital foramen, where it continues the medulla oblongata, and terminating in a point at the upper third of the sacral canal, or a little beyond that, giving off at each side, during its course, the superior and inferior roots of the spinal nerves.

Weight.—In medium-sized animals, the weight of the cord is represented by the following approximate numbers: for the Horse, 10½ ounces; the Ass, 5¼ ounces; Cow, 7¾ ounces; Sheep and Goat, 1¾ ounces; Pig, 2½ ounces; Dog, 1¼ ounces; Cat, 4½ drams; and Rabbit, 3¼ drams.

Shape and volume.—The spinal cord is slightly flattened above and below, throughout its whole length; in whatever part we examine a transverse section of it, we shall always find the lateral diameter greater than the vertical, and that this section appears regularly elliptical.

The flattening is more marked in the lumbar than in any other region.

Its volume is far from being uniform. In following it from before to behind, we at first remark that it presents the same dimensions to the fifth cervical vertebra, and that between this point and the second dorsal vertebra it forms an oblong enlargement, designated the *brachial cervical enlargement* (or *bulb*). Beyond this, it assumes its original volume, and even becomes gradually smaller than in the cervical region. Towards the middle of the loins, it again enlarges to constitute the *lumbar enlargement* (or *bulb*), which extends to the entrance of the sacral canal. After this dilatation comes a conical prolongation (*conus medullaris*), the point of which represents the terminal extremity of the cord.

If we compare the diameter of this cord with that of the spinal canal, we shall observe, as has been already said, that the capacity of the containing cavity is generally related to the volume of its contents, and that the former is, as a rule, most capacious at the cervical and lumbar enlargements. It will even be noticed that the dilatation the spinal canal offers at these two points, is relatively more considerable than the increase in volume of the cord. This is because the mobility of the spine, which is very great in these two regions, requires this difference to secure the spinal axis from injury during the movements executed by the vertebral column. This protective combination is also found elsewhere—at the atlas, for example, where we know motion is considerable; and throughout the entire extent of the cervical region, which in this respect greatly exceeds the dorsal region.

Means of fixture.—The cord is relatively fixed in its envelopes by: 1. Its continuity with the brain. 2. The coccygeal ligament. 3. The dentated ligaments.

External surface of the cord.—Covered by the pia mater, this surface presents an extremely simple disposition. On its superior and inferior planes, at each side, we remark the double series of sensitive and motor roots of the spinal nerves, which are implanted in the same longitudinal line to right and left of the middle plane, and are collected in fasciculi opposite the intervertebral foramina.

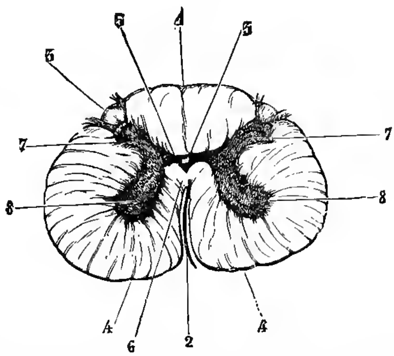
In the middle line, and throughout the entire length of the cord, there are two deep and narrow fissures: one *superior* (*fissura longitudinalis superior*), the other inferior (*fissura longitudinalis inferior*), into which the pia mater enters. Four other fissures have been described at the point of emergence of the nerve-roots, by the names of *superior* and *inferior collateral fissures* (or *sulci*); but the two superior alone exist, and even these are often scarcely noticeable, being rather indicated by the origin of the nerve-roots.

INTERNAL CONFORMATION AND STRUCTURE OF THE SPINAL CORD.

In making a transverse section of any portion of the cord, we may convince ourselves that it has an internal cavity. This *central canal* is elliptical, and lined by a simple layer of columnar ciliated epithelium, resting on a thin connective membrane—the *ependymis* of Virchow. (The cilia of these cells are only to be seen in early life; in advanced age the canal may be closed, the cells then becoming much altered in form from pressure. The canal is immediately surrounded by spongy horny matter.) This section also shows the two median fissures mentioned in describing the exterior of the cord, the inferior of which is wider and deeper than the superior, the situation of the latter being scarcely perceptible.

These two fissures lie one before the other, and do not meet so as to completely divide the cord into two lateral halves, but remain separated by two thin horizontal and superposed bands of nerve matter, that pass from one end to the other of the medullary axis. The inferior, formed of white substance, corresponds to the bottom of the inferior fissure; while the superior, composed of grey matter, meets the superior fissure.

Fig. 418.



SECTION OF THE SPINAL CORD OF THE HORSE AT THE LUMBAR REGION. MAGNIFIED TWO DIAMETERS.

1, Superior median fissure; 2, inferior median fissure; 3, 3, superior collateral fissures; 4, 4, inferior ditto; 5, grey commissure; 6, white commissure, 7, 7, superior grey cornua; 8, 8, inferior grey cornua; 9, central canal.

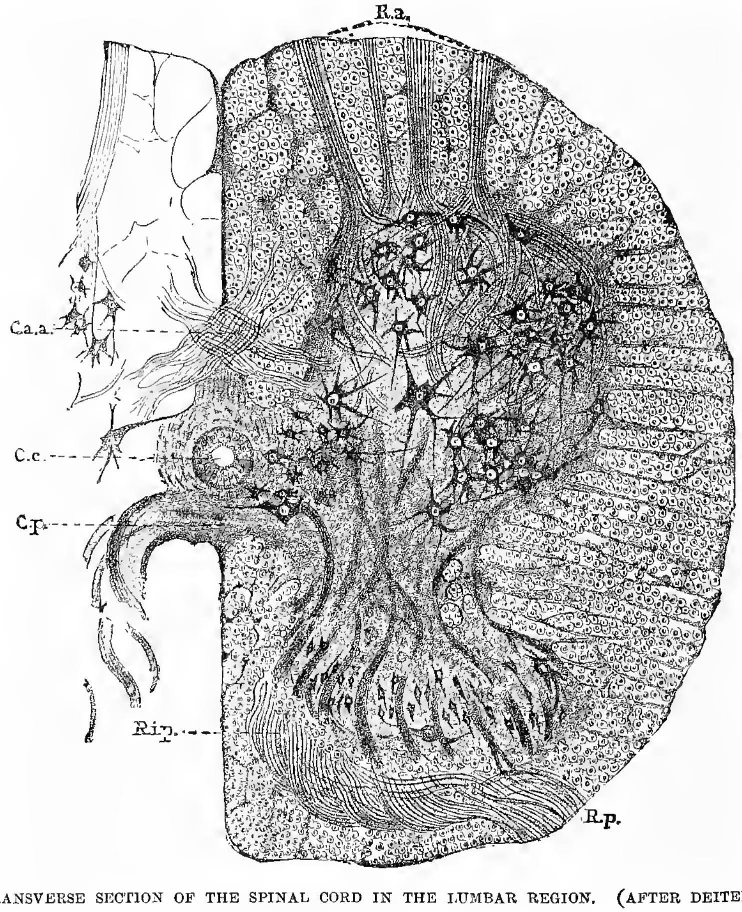
These bands are named the *white* and *grey commissures* of the spinal cord (Figs. 418, 419, 420).

Notwithstanding the presence of these two commissures between the lateral halves of the spinal axis, these latter do not the less constitute two symmetrical systems, the structure of which will now be studied.

Each medullary cord represents a semi-cylinder of white substance, in the centre of which is a mass of grey matter, that varies somewhat in quantity in different regions, but the arrangement of which is everywhere the same. Thus, inwardly, this grey matter joins the grey commissure; above, it sends off a thin prolongation that traverses the substance of the medullary cord (*superior grey cornu*), to reach the bottom of the superior collateral fissure; below, it gives rise to an analogous, though a thicker and a more irregular, prolongation (*inferior grey cornu*), which is directed well in front of the inferior roots, but does not reach the surface of the cord. In consequence of this arrangement, the grey substance of the cord forms altogether a kind of capital H, the horizontal branch of which is perforated in the middle by the central canal.

This arrangement of the grey substance causes the white matter to be divided, in each lateral moiety of the spinal axis, into three *cords* or *secondary columns*; the *superior* of these is perfectly isolated, and is comprised between the middle superior fissure and the origin of the sensitive roots; another, the *inferior*, united to that of the opposite side by the white commissure, is limited, inwardly, by the inferior median fissure, and outwardly by the line of origin of the motor nerve-roots; while a third—the *lateral* or *intermediate*—thicker than the others, is confounded superficially with the inferior, and formed by all that portion of the cord situated between the lines of origin of the superior and

Fig. 419.



TRANSVERSE SECTION OF THE SPINAL CORD IN THE LUMBAR REGION. (AFTER DEITERS.)

R.a., Inferior root; R.p., superior root; R.i.p., internal portion of the superior root; C.p., superior commissure; C.a.a., inferior commissure; C.c., central canal. The network of myeline fibres in the grey substance, as well as those in the inferior grey commissure, are not indicated.

inferior roots. Of these three columns, the first is sensory; the other two—which in reality are only one—are not.[1]

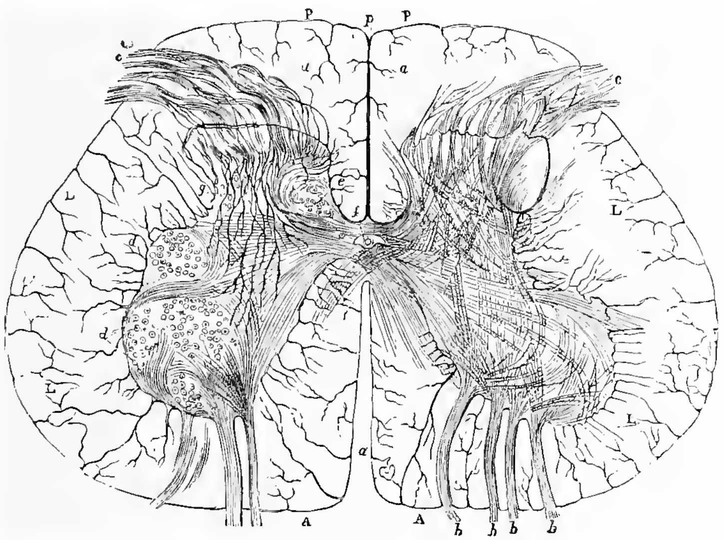
[1] The existence of so-called "systematic lesions" in Man has led anthropotomists to distinguish, in the white substance of the cord, a great number of regions. Thus, the innermost portion of the anterior column (inferior in animals) is designated *Türck's fasciculus;* the corresponding portion of the posterior column (superior) in the cervical region is *Goll's column;* the *lateral column* is rigorously limited by the grey cornua; while the regions around these latter are named the *anterior* and *posterior radicular zones.*

In adhering to the facts of normal anatomy, it must be admitted that some of these distinctions are in great part artificial. Nevertheless, there are found on the limits of certain

STRUCTURE.—Independently of the epithelium mentioned when describing the ependymis, neuroglia, nerve-fibres, nerve-cells, and vessels enter into the structure of the spinal cord.

The *neuroglia* has been compared to a kind of sponge (the so-called spongy matter), in the spaces of which are the other elements of the cord. It exists in the white and the grey matters, but it is more abundant in the superior grey cornua than in the inferior cornua. It surrounds the upper extremity of the former, in becoming softer and more transparent, and is here designated the *gelatinous substance of Rolando* (*substantia gelatinoso Rolandi*). It constitutes,

Fig. 420.



TRANSVERSE SECTION OF SPINAL CORD THROUGH THE MIDDLE OF THE LUMBAR REGION, SHOWING ON THE RIGHT SIDE THE COURSE OF THE NERVE-ROOTS, AND ON THE LEFT THE POSITION OF THE PRINCIPAL TRACTS OF VESICULAR MATTER.

A, A, Inferior columns; P, P, superior columns; L, L, lateral columns; *a*, inferior median fissure; *p*, superior median fissure; *b*, *b*, *b*, *b*, inferior roots of spinal nerves; *c*, *c*, superior roots; *d*, *d*, tracts of vesicular matter in superior column; *e*, tracts of vesicular matter in inferior column *f*, central canal; *g*, substantia gelatinosa.

in great part, the grey commissure, and can be deeply stained by the carminate of ammonia.

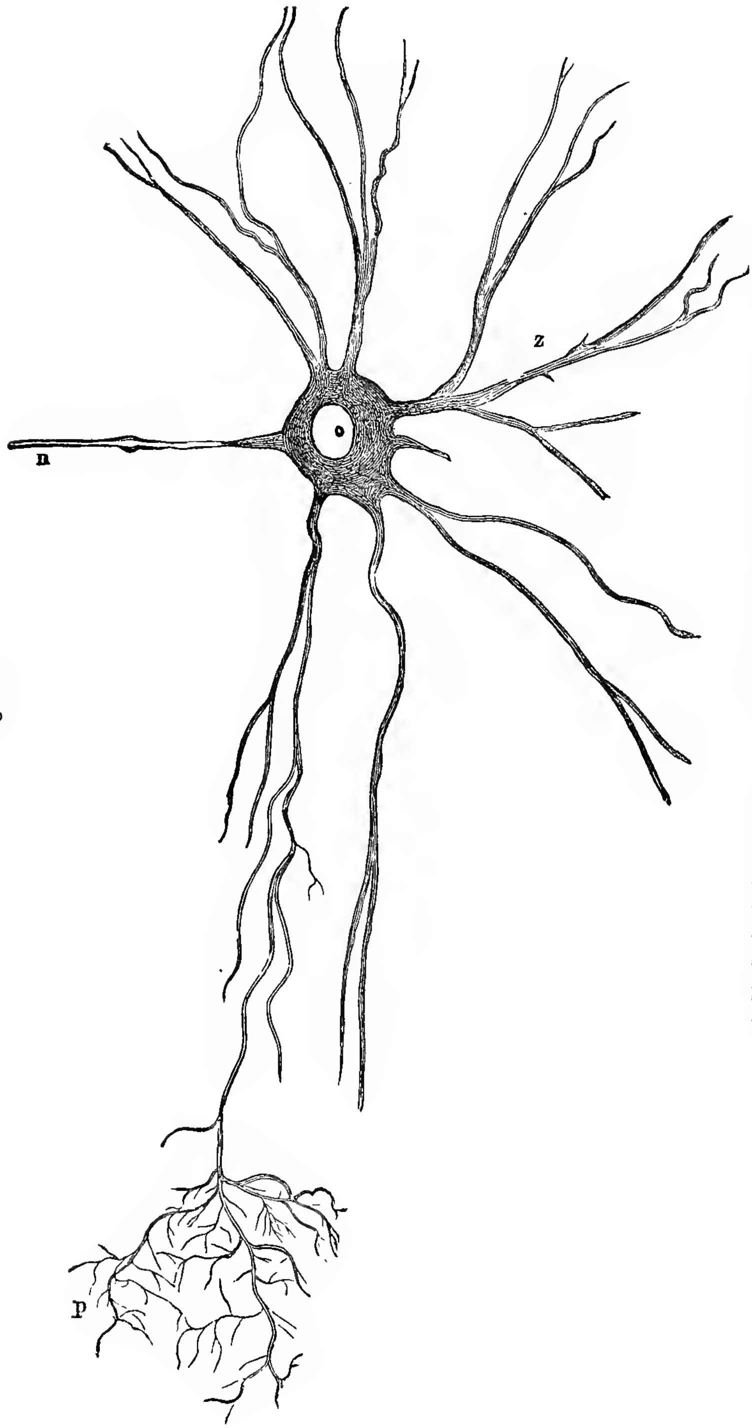
The neuroglia is associated with a small quantity of connective tissue, which enters the cord along with the vessels. It is formed of a mass of cells, the mem-

regions either a depression on the surface of the cord, or on its substance a fasciculus of connective tissue, or a vessel larger than in other points.

The systematic lesions of the cord not having yet been observed in the domestic animals, it cannot be stated at what point the distinctions established in the human spinal cord are justified, so far as that of the Horse is concerned. In some sections of the cord of that animal, it would appear that the fasciculus of Türck is distinct from the other parts of the anterior column; but in a great number the separation is extremely vague. The columns of Goll alone are very distinct in the superior portion of the cervical region. They are especially visible in the Dog.

In fact, at the present time the topography of the human spinal cord cannot be without uncertainty when applied to that of animals; but the efforts of pathologists and anatomists should be directed to dissipating this uncertainty.

Fig. 421.



A GANGLIONIC CELL FROM THE INFERIOR CORNU OF THE SPINAL CORD.

n, Cylindraxile of Deiters; z, protoplasmic prolongations which subdivide into several ramifications.—P.

branous bodies of which, irregularly stellate, send numerous prolongations between the nerve-tubes and cells.

(In the substantia gelatinosa on the superior surface of the cord is a network of fine fibrils, epithelial in its nature, and consisting of cuticular matter; this is known as the *granular matter*, or *spongy horn-substance*.).

The *fibres* and *cells* form, with the neuroglia, the whole of the grey substance.

The *cells* have a more or less large number of protoplasmic prolongations which ramify and anastomose, or have a process—the *prolongation of Deiters*—which puts them in communication with a nerve-tube. They are more or less voluminous.

The *fibres* of the grey substance are all very fine, and some have a sheath of myeline; the others are reduced to an axile filament.

In the Horse, the cells are not universally distributed throughout this substance, but are collected in small masses which form longitudinal columns. The largest are grouped in three small masses around the inferior cornu—one external, another internal, and the third at the extremity; the latter is the most considerable. They are in relation with the motor roots of the nerves.

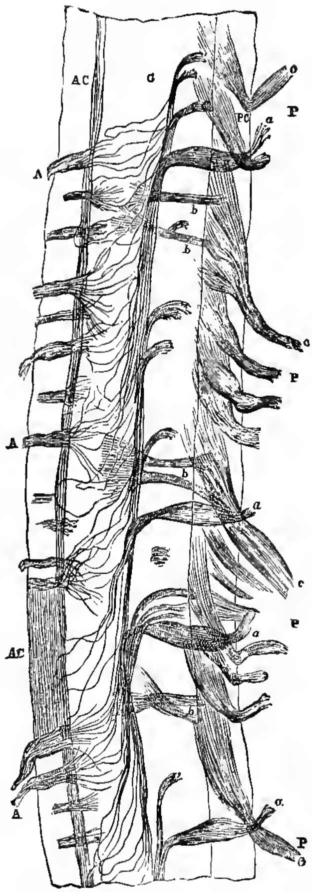
Some are spread in the middle part of the grey substance, and principally opposite the point where the grey commissure joins the cornua. There they form *Lockhart Clarke's column*.

A small number are placed on the margin of the superior grey cornu, and these, as well as the cells of Clarke's column, receive radicular filaments from the spinal sensory nerves.

Finally, some form an external column (*column of Burdach*) at the junction of the two cornua, whence emerges, above, the small nerve of Wrisberg. They are probably connected with the vaso-motor phenomena.

The nerve-tubes (or tubules) affect longitudinal, transversal, oblique, and vertical directions. They bring the cells of one lateral moiety of the medulla into communication with: 1. The tubes of the white substance which pass towards the brain. 2. Each other. 3. The cells of the opposite moiety, by passing into the commissures. 4. The tubes of the white substance of the opposite moiety, by following the same course.

Fig. 422.



LONGITUDINAL SECTION THROUGH CERVICAL ENLARGEMENT OF SPINAL CORD OF CAT.

AC, Inferior white columns; AC′, portion showing the arrangement of the longitudinal fibres; PC, posterior white columns; G, grey substance between them (the vesicles being omitted to avoid obscuring the course of the fibres); A, anterior roots of the nerves; P, posterior roots, consisting of three kinds: the first, *a*, crossing the posterior columns horizontally, and then passing obliquely downwards, across the grey substance, into the anterior columns; the second, *b*, traversing the posterior columns horizontally, and then losing themselves in the grey substance; the third, *c*, for the most part becoming continuous with the longitudinal fibres of the posterior column; all, or nearly all, ultimately entering the grey substance.

The *neuroglia* and *nerve-tubes* constitute the *white substance*, which is arranged, as we know, into three columns at least. All the tubes of this substance do not ascend to the brain, as was believed for a long time; the opinion that the tubes of the spinal nerves formed the medulla and extended to the brain, has been abandoned since Volkmann measured, comparatively, the section of all these nerves and that of the nervous spinal-axis.

The tubes or fibres of the white substance have not always the same composition, nor the same size. Many have no enveloping membrane, and those which possess one have not a nucleus; so that it is difficult to regard this as a true sheath of Schwann. Certain anatomists, however, consider them to be so, but without the constriction (Ranvier); while others admit that they are so provided, like the elements of the nerves (Tourneur and Legoff).

These tubes are thick in the inferior columns, and uniformly smaller in the superior ones. A mixture of fine and thick tubes is observed in the lateral columns, but the finest are always generally towards the grey substance.[1]

(Volkmann has established the fact, that the size of the medulla corresponds with the number of nerve-tubes given off at any point. He gives the weight of four segments, each $2\frac{4}{5}$ inches in length, from the spinal cord of the Horse, and the relative extent of the grey matter in square lines; these are as follows:—

	Grains.	Area of grey matter.	Area of white matter.
From below 2nd spinal nerve,	219	13	109
„ „ 8th „ „	293	28	142
„ „ 19th „ „	163	11	89
„ „ 30th „ „	281	25	121)

In the white substance the tubes are longitudinal, oblique, or transversal; the latter arise from the cells of the grey substance, and form the roots of the nerves emerging either by the superior or inferior collateral fissure.

The tubes of the inferior columns pass to the cells of the grey substance, or reach the brain by remaining in the corresponding moiety of the cord—the fibres of the right half of the medulla gaining the brain without passing into the left half. Those of the lateral columns decussate, each sending to, and receiving from, the other, tubes which cross in the white commissure. The superior columns contain fibres that extend directly to the brain; these are sensorial. There are also found transverse fibres that enter the cells of the superior grey cornua, and others that pass into the cells of the inferior or motor cornua.

Such is, in a few words, the arrangement of the nerve-elements in the spinal cord. The subject is a very long and complicated one, which cannot be dealt with in a more detailed manner in an elementary work on descriptive anatomy.

Vessels.—In the spinal cord the grey is richer in vessels than the white substance. The capillary networks are finer in the former than the latter, and chiefly in the vicinity of the nerve-cells.

Arterial blood enters the cord by three orders of vessels: 1. The *median arteries*, which pass into the inferior and superior middle fissures. 2. The *radicular arteries*, which follow the roots of the spinal nerves. 3. The *peripheral arteries*, which arise from the vascular ramifications of the pia mater (Duret). The vessel which furnishes these divisions is the middle spinal artery.

[1] There is a tendency now to the belief that these slender tubes serve for the conveyance of sensory impressions. An alteration in them is coincident with deranged sensibility.

The *veins* are proportionately large. Two are lodged in the grey commissure; and a third, which is voluminous, lies in the middle superior fissure.

All the vessels are accompanied by the slender nerves disposed in plexuses issuing with the *communicating* veins, or the superior radicles which they follow into the substance of the cord.

In the cord there are *perivascular lymph spaces*, which probably open into the deep layer of the pia mater.

Differential Characters in the Spinal Cord of the other Animals.

In all the species, the white and grey substances affect the disposition above described; only some slight differences in the reciprocal volume of each have been remarked. As in the Horse, the spinal cord does not extend beyond the sacral region. Its length has no relation to that of the coccygeal region, as certain anatomists would, in principle, establish; in the Rabbit, for example, the tail of which is very short, the spinal cord is prolonged into the coccygeal vertebræ.

Comparison of the Spinal Cord of Man with that of Animals.

The spinal cord of adult Man does not reach beyond the first lumbar vertebra, though in the fœtus it is in the coccyx. It is rounder than in the Horse, and the grey substance is, relative to the white, more abundant than in the spinal cord of the domesticated animals. The posterior grey cornua are also larger and less elongated, than the superior cornua in the Horse; and the roots of the nerves are also more voluminous than in that animal.

No nerve-cells are found in the posterior cornua, and Clarke's column is limited to the dorsal region; so that the sensitive nerves of the back and loins arise in the dorsal region. The nerves of the cervical region arise from a series of nuclei arranged in the medulla oblongata.

CHAPTER III.

THE BRAIN, OR ENCEPHALON.

Article I.—The Brain as a Whole.

The *brain* is that portion of the nervous system which is lodged in the cranial cavity. It succeeds, without any line of demarcation, the spinal cord, of which it may be considered, with regard to its figure, as a kind of efflorescence.

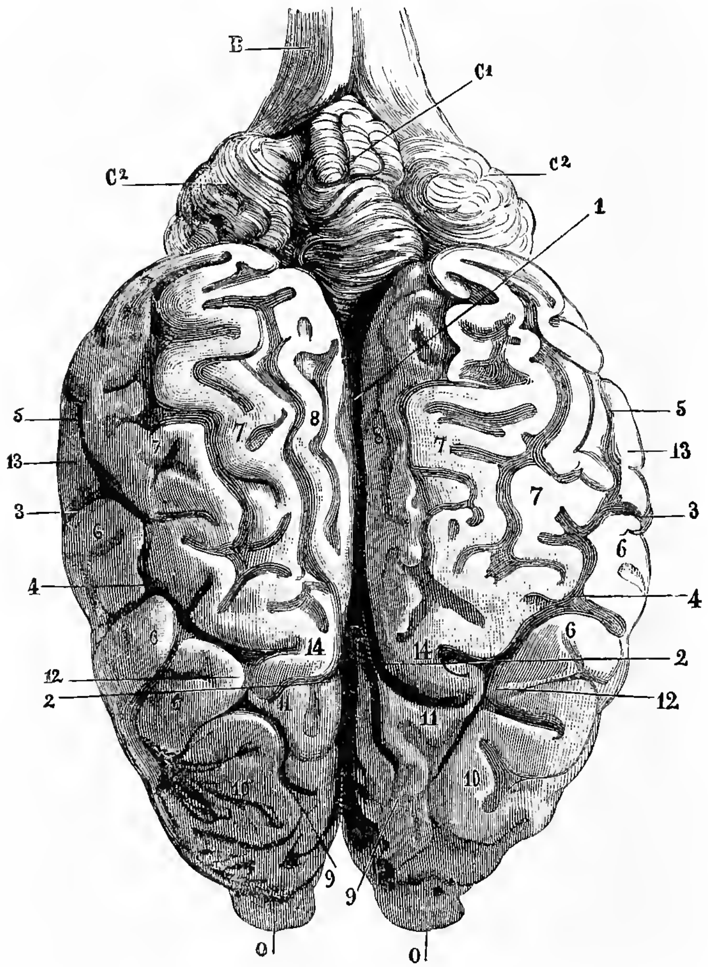
General form and composition.—In shape it is an ovoid mass, elongated from before to behind, and very slightly depressed above and below.

When it is viewed on its superior face (Fig. 423), we first see, behind, a white pedicle—the prolongation of the spinal cord—and a single lobe of a grey colour designated the *cerebellum*. In front of this is remarked two other lobes, separated from the first by a deep transverse fissure, into which the tentorium cerebelli passes. Isolated from one another on the middle line by a shallower fissure, these two lobes constitute the *brain*, and are usually named the *cerebral hemispheres*.

In turning over the brain to examine its inferior face, we see that the posterior peduncle of the organ—a continuation of the spinal cord—is prolonged beneath the cerebellum, which is joined to the lateral parts of its superior face; this portion then enters the cerebral hemispheres by their inferior face, behind two thick white cords—the optic nerves—which mark the anterior limit of this prolongation (Fig. 424). This is the *isthmus of the brain*—a name given to it because it actually forms an intermediate bond between the three enlargements which form the principal mass of the organ.

The cranial portion of the central nervous mass is, then, composed of three

Fig. 423.



BRAIN OF THE HORSE (UPPER SURFACE). THREE-FOURTHS THE NATURAL SIZE.

1, Great longitudinal or inter-hemispherical fissure; 2, 2, crucial fissure; 3, 3, fissure of Rolando; 4, 4, its anterior branch; 5, 5, its posterior branch; 6, 6, plaits of the ascending frontal convolution; 7, 7, the two plaits of the external parieto-occipital convolution; 8, 8, internal parieto-occipital convolution; 9, 9, first frontal convolution; 10, 10, second frontal convolution; 11, 11, sigmoid gyrus, often concealed by the annectent gyrus of 12, which joins the ascending frontal convolution of the second frontal; 13, lobule of the curved plait; 14, 14, annectent gyrus uniting the two parietal convolutions to the sigmoid gyrus, and through it to the frontal convolutions. O, O, Olfactory bulbs; B, medulla oblongata; C[1], middle lobe of the cerebellum; C[2], lateral lobes of ditto.

apparatuses: the *isthmus of the brain*—a prolongation of the spinal cord; and the *cerebellum* and *cerebrum*—bulbous lobes grafted on the superior face and anterior extremity of this peduncle. These three divisions are very well seen in their entirety and reciprocal relations in Fig. 424. We will study them separately and in succession.

Volume of the brain.—Contrary to what is found in the spinal cord, the dimensions of the brain closely represent those of the cavity containing them: the visceral layer of the arachnoid lying everywhere immediately on the proper envelope of the nervous mass—the pia mater—except at the sub-arachnoid spaces; and, on the other hand, the arachnoid cavity can scarcely be said to exist while the dura mater is, as it were, glued to the cranial walls, and in reality constitutes their internal periosteum.

The brain has, therefore, no room to move in its receptacle, but is maintained in it in an almost absolutely immovable condition, which coincides exactly with that of the sutures or cranial articulations.

Weight.—The total weight of the brain, in average-sized animals, may be inferred from the following figures: Horse, 22 oz. 15 drams; Ass, 12 oz. 11 drams; Ox, 16 oz. 15 drams; Sheep and Goat, 4 oz. 9⅓ drams; Pig, 5 oz. 10 drams; Dog, 6 oz. 5½ drams; Cat, 1 oz. 1 dram; Rabbit, 5½ drams.

Cornevin has remarked that the cranial capacity, if not the weight of the brain, is greater in the female than in the male of the domestic species and breeds of animals.

In comparing these figures with those of the spinal cord, it will be seen that the relative weight of the latter to that of the encephalic mass differs notably in the several animals, being highest in the Dog, and lowest in the Rabbit. The relations in each species, between the two divisions of the nervous system, are the following: Dog, 1 : 5·14; Cat, 1 : 3·75; Sheep and Goat, 1 : 2·60; Ass, 1 : 2·40; Pig, 1 : 2·30; Horse, 1 : 2·27; Ox, 1 : 2·18; Rabbit, 1 : 2. We give these numbers, as it has always been attempted to establish, in the predominance of the brain, the cause of the development of intelligence, and that the best measure of this predominance is really the relation of the spinal cord to the brain. It has also been attempted to measure this predominance of the brain by comparing its weight with that of the entire body; but it is sufficient to cast one's eye over the tables drawn up with this view in several anatomical and physiological works, to be convinced that this basis does not possess all the value desirable.

Preparation of the brain.—To study the brain, it is necessary to extract it from its bony receptacle; a result achieved in two ways. The first consists in opening the roof of the cranium by hammer and chisel, after removing from its exterior all the parts covering it, or which are in its vicinity. The dura mater is then excised with scissors, and the brain, which is thus directly reached, is completely isolated by raising its posterior extremity, and cutting from behind to before all the nerves passing through the foramina at the base of the cranium, with the pituitary stem, as well as the extremity of the olfactory bulbs. This method is very expeditious, but it sacrifices the pituitary gland, which remains firmly embedded in the sella Turcica—an inconvenience we obviate by resorting to the second procedure. In this, the cranium is opened by its base or floor, after separating the head from the trunk, cutting away the lower jaw, tongue, and os hyoides, and excising all the soft parts so as to expose the bony surfaces. The head, thus prepared, is held by an assistant, the roof of the cranium resting on a table or block. Armed with a chisel and hammer, the operator first removes the zygomatic arches and the styloid processes of the occipital bone, then the condyles of this bone, the basilar processes, and the sphenoid, palatine, and ethmoid bones, returning to the lateral portions of the cranium, which are chiselled away in succession from the occipital to the ethmoid bones. The brain, being sufficiently exposed, is relieved from its dura mater as in the first method, and raised in the left hand to destroy, by means of scissors held in the right hand, the attachments which yet fix it to the cranial roof, and which are chiefly the veins that open into the sinuses of the dura mater. In afterwards excavating the ethmoidal fossæ with the point of a scalpel, the olfactory bulbs are detached and the mass is free. This procedure is more difficult than the first, but possesses several advantages over it; for not only do we preserve the pituitary gland, but have the ethmoidal lobes more intact, and may also have, if desired, the ganglia of the cranial nerves, with a more or less considerable portion of the nerves themselves.

After indicating the methods for extracting the brain from its bony case, we ought to say some words as to the course to be pursued in order to study it successfully. To do this it is advantageous to have two brains; one of these should be hardened by steeping it for some weeks in alcohol (or methylated spirit), or in water to which has been added a tenth part of nitric acid. This hardening contracts the nerve substance, and causes the cavities and reliefs to appear more manifest. (It is a good plan to place the brain, base uppermost, in a suitable vessel, and if a piece of cloth be spread beneath it, its removal therefrom will subsequently be greatly facilitated.)

We commence by examining rapidly the whole apparatus, and pass immediately to the study of the isthmus, of which it is necessary to have at first a well-defined idea. We therefore take a hardened specimen, and isolate this portion of the brain in the manner represented in Fig. 425; to do this, it suffices to cut through the peduncles of the cerebellum, and excise the cerebral hemispheres upwards and backwards; the remains of these and the cerebellum should be preserved for an analysis of their structure. The isthmus thus isolated is fitted for an examination of its external conformation and its internal cavities—the ventricle of the optic layers and the aqueduct of Sylvius—into which we may penetrate by a superior longitudinal incision.

After the isthmus, the cerebellum is to be studied—in its external conformation—on an intact specimen: and in its internal conformation and structure on the incised piece.

We terminate with the cerebrum, the superficies of which is soon examined; its interior should be studied in the following manner: It is necessary to begin by demonstrating the existence of ventricles in the olfactory lobes, and their communication with all the other internal cavities of the brain, which can easily be done by the inflation of one of these organs by means of a straw (or dissecting-case tube), which raises the pituitary gland, the cerebrallobes and the cerebellum. Then we pass to the corpus callosum, which is exposed, as in Fig. 434, by a horizontal section of the hemispheres across the centrum ovale. The corpus callosum of each side is afterwards excised in the middle line to reach the interior of the lateral ventricles, and this great commissure of the brain ought, after studying the septum lucidum, to be cut across in the middle and turned over, as in Fig. 435, so as to show the fornix. The foramen of Monro is next examined; then the corpus striatum, hippocampi, tænia semicircularis, choroid plexus, and velum interpositum, which are exposed by the ablation of the hippocampi and fornix Lastly, we return to the foramen of Monro to study its communication with the ventricle of the optic thalami; it will be well, also, to again examine the latter, as well as the aqueduct of Sylvius and the ventricle of the cerebellum, which we arrive at in dividing that organ through the middle and separating the halves.

Two longitudinal and vertical sections, one median (Fig. 428), the other at the side (Fig. 431), will not be without utility in the study of these particulars. They may be made by means of a saw, the brain remaining enclosed in the cranial cavity.

(A useful implement I have employed for removing the bony casing of the brain without risk of injuring the latter, is a chisel with a thin cutting edge which is slightly concave, the corners being smooth and rounded, and projecting beyond the cutting edge.)

The brain may be preserved for an indefinite time when it has undergone the following preparation: 1. Place it for from twelve to fifteen days in a solution of nitric acid (10 to 100). 2. Then leave it for a week in a solution of bichromate of potassium (20 to 1000). 3. Afterwards steep it for three or four days in alcohol at 40°. 4. Take it from the alcohol, allow the latter to evaporate, then put it in a paraffin bath for from ten to fifteen minutes, not allowing it to boil. 5. Withdraw it from the paraffin and allow it to dry. After this series of preparations the brain shrivels, but it preserves its shape, and will not putrefy.

Article II.—The Isthmus (or Medulla Oblongata).

We will study in succession the external and internal conformation of this part, and its structure.

External Conformation of the Isthmus.

The *isthmus*, or *medulla oblongata*, is a prismatic prolongation of the spinal cord supporting the cerebellum, and terminating in the cerebral hemispheres;

it increases in size from behind to before, and may be considered as having four *faces* and *two* extremities.

The *inferior face* (Fig. 424), on which we can distinctly, and without any preparation, perceive the natural limits of the isthmus, is crossed nearly in its middle by a thick fasciculus of arciform fibres, which constitute the *annular protuberance* (*protuberantia annularis*), *pons Varolii*, or *mesocephalon* (or *nodus encephali*). All the portion lying behind this fasciculus belongs to the *medulla oblongata*. That in front forms the *cerebral peduncles* (*crura cerebri*).

The *superior face* (Fig. 425), covered by the cerebellum and the posterior extremity of the cerebral lobes, is more mammillated than the preceding. Passing from behind to before—on the superior face of the medulla oblongata—there is remarked the section of the *peduncles of the cerebellum*, the *valve of Vieussens*, the *corpora quadrigemina*, and the *thalami optici*.

The *lateral faces* (Fig. 426), concealed in their anterior part by the hemispheres of the brain, exhibit the profile of the medulla oblongata, pons Varolii, peduncles of the cerebellum (*crura cerebelli*), cerebral peduncles (*crura cerebri*), corpora quadrigemina, and thalami optici.

The *posterior extremity* of the isthmus belongs to the spinal bulb, and continues the spinal cord, from which it is only distinguished artificially.

The *anterior extremity* is enveloped below, and on each side, by the oblique fasciculi which form the two optic nerves, and beneath which are insinuated the fibres of the isthmus before they pass into those parts of the cerebral hemispheres which bear the name of *corpora striata*.

After this enumeration of all the parts which constitute the isthmus of the brain, we will examine them in detail, and in the following order: 1. *Medulla oblongata*. 2. *Pons Varolii*. 3. *Crura cerebri*. 4. *Crura cerebelli*. 5. *Valve of Vieussens*. 6. *Corpora quadrigemina*. 7. *Thalami optici*. After these we will describe the *pineal* and *pituitary glands*—small appended lobes placed, one on the superior, the other on the inferior face of the isthmus.[1]

1. Medulla Oblongata (Figs. 424, 425, 426).

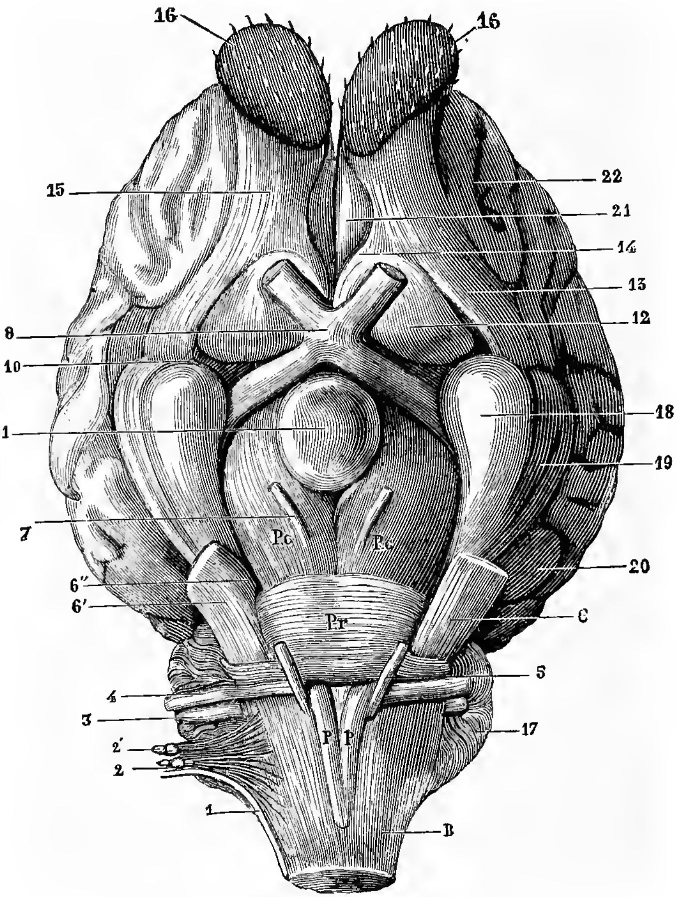
The *medulla oblongata* constitutes the posterior portion of the encephalic isthmus; it succeeds the spinal cord, and extends forward as far as the pons Varolii. It is a thick peduncle of a white colour, wider before than behind, flattened above and below, and having four *faces*—an *inferior*, *superior*, and two *lateral*.

Inferior face (Fig. 424).—This face rests in the channel of the basilar process. Convex from side to side, and limited anteriorly by a transverse fissure which separates it from the pons Varolii, posteriorly it does not offer anything to distinguish it from the spinal cord.

[1] There is far from being any agreement as to the number of parts which ought to compose the encephalic isthmus, some authorities making more, some less. The limits of this small apparatus will, nevertheless, be found perfectly circumscribed if it be examined in the lower animals, and particularly in the Horse. An antero-posterior section of the brain, made to one side of the middle line, appears to us all that is needed to definitely settle the point. This section, seen in Fig. 428, shows in the clearest manner that the encephalic prolongation of the spinal axis extends to the corpora striata, and that it comprises the medulla oblongata, pons Varolii, cerebral and cerebellar peduncles (or crura), the corpora quadrigemina, and the thalami optici. All these, then, belong to one and the same system—the medullary prolongation, which serves as a bond of union between the three principal masses of the brain, and which we have designated the *isthmus*. It may be added, that this manner of considering the encephalic isthmus perfectly agrees with the teachings of physiology.

On the middle line there is a well-marked fissure—a continuation of the inferior fissure of the cord—which lies between two very elongated prominences that are sometimes but little apparent, and which, from their form, are named the *corpora pyramidalia* (Fig. 424, P, P). The base of these pyramids touches

Fig. 424.



GENERAL VIEW OF THE HORSE'S BRAIN (INFERIOR FACE).

B, Medulla oblongata; P, P, pyramids of ditto. 1, Internal root of the spinal accessory nerve; 2, external roots of ditto; 2′, roots of the pneumogastric nerve; 3, root of the auditory nerve; 4, root of the facial nerve; 5, sixth nerve; 6, root of the fifth nerve; 6′, 6″, motor and sensory roots of the fifth nerve. P.c, P.c, crura cerebri. 7, Third nerve; 8, optic commissure; 10, fissure of Sylvius; 11, pituitary gland; 12, extra-ventricular nucleus of the corpus striatum; 13, external root of the olfactory bulb; 14, internal root of ditto; 15, olfactory bulb; 16, 16, grey nuclei from which proceed the olfactory nerves; 17, lateral lobe of the cerebellum; 18, temporal lobe of the brain; 19, first temporal convolution; 20, lobule of the curved plait; 21, gyrus rectus; 22, frontal lobe (antero-external face).

the pons Varolii, and their apex is insensibly lost, posteriorly, on reaching the spinal cord.

Outwardly is an almost plane surface, bordered anteriorly by a transverse band (Fig. 330) which lies immediately behind the pons Varolii; sometimes it is covered for the greater part of its extent by a very thin expansion of *arciform* *fibres*, between the anterior border of which and the transverse band—and particularly in pieces that have been hardened by alcohol or acidulated water—is seen a slight oblong prominence which corresponds to what in Man is designated the *corpus olivare.*[1] This is isolated from the pyramid by a longitudinal groove, whence emerge, in front, the roots of the sixth cranial pair, and behind, those of the twelfth pair; outwardly, it is limited and separated from the restiform body by the origin of the majority of the roots belonging to the glosso-pharyngeal and pneumogastric nerves.

Superior face.—Covered by the cerebellum, it is channeled in its middle by an excavation (Fig. 424, 5), which constitutes the floor of the fourth ventricle. This cavity is prolonged forward above the pons Varolii, between the crura cerebelli, and from its forming an angle behind, resembling the point of a pen, it has been named the *calamus scriptorius.*[2]

Two thick cords, prolongations of the superior fasciculi of the medulla spinalis, border the calamus scriptorius on each side; these are designated the *corpora restiformia.*[3] Lying together at their posterior extremities, they separate anteriorly, so as to represent the branches of a V (Fig. 425, 1).

Lateral faces.—Much narrower than the other two, and showing two thick borders, these faces give the profile of the corpora restiformia (Fig. 426, 2), corpora pyramidalia (4), and the fasciculus between these two.

2. **The Pons Varolii** (Figs. 425; 426, 5).

The *pons Varolii*—also named the *tuber annulare*, or *mesocephalon*—is that part of the brain which stands out prominently across the isthmus, between the medulla oblongata and the crura cerebri, and which is lodged in the anterior depression of the basilar process.

It is a semicircular band of white transverse fibres thrown across, like a bridge, from one side to the other of the cerebellum. It has two faces. The *superior face* is adherent to the fasciculi of the medulla oblongata, which is prolonged to form the crura cerebri.[4] The *inferior face* is in every sense convex, wider in its middle than in its lateral portions, and crossed from behind to before by a shallow median groove for the basilar artery. It offers for consideration two *borders* and two *extremities*.

The *posterior border*, slightly convex, is separated from the medulla oblongata by a slight groove.

[1] This prominence corresponds to the *corpus olivare* of Man only in its position, as it has not its structure; for the former has a grey nucleus in its substance, which is divided into two small masses, the superior of which is found in Ruminants.

[2] In the bulbar portion of the *calamus scriptorius*, are seen the diversely coloured prominences which correspond to the origin or course of some cranial nerves. These are—viewing them from behind to before, and within to without, commencing at the middle fissure—the *internal white ala*, corresponding to the nucleus of the hypoglossal nerve; the *grey ala*, corresponding to the nuclei of the pneumogastric, spinal, and glosso-pharyngeal nerves; the *external white ala*, situated above the auditory nucleus; lastly, the *eminentia teres*, placed between the middle fissure and the crura cerebelli, lodging the bend in the root of the facial nerve.

The point of the *calamus scriptorius* is covered by a small white layer extending from one border to the other, named the *bolt*, the cavity beneath this being designated the *ventricle of Arantius*, at the bottom of which is usually seen the opening of the central canal of the spinal cord.

[3] The *posterior pyramids* are formed by the bulbar prolongation of the grey column of the spinal cord; they pass to the right and left, and disappear towards the posterior crura cerebelli; they expand near the summit of the calamus scriptorius, and at this point possess very great excitability.

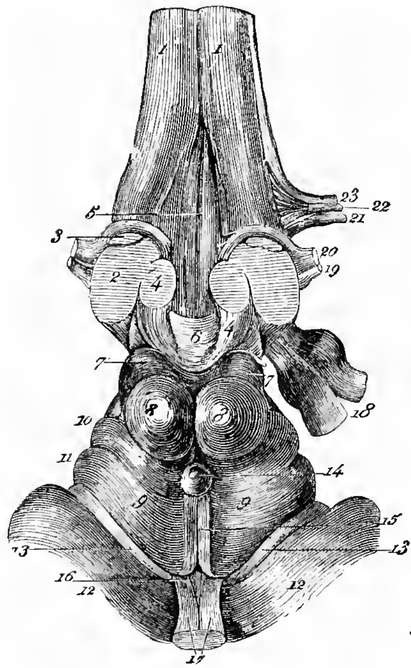
[4] Some authorities carry the superior face of the pons to the floor of the fourth ventricle.

The *anterior border*—also convex, but indented in its middle—largely overhangs the crura cerebri, which are limited on this side by a well-marked fissure.

The *extremities* are bent upwards to enter the substance of the cerebellum, in the form of two thick cords, which constitute the middle crura cerebelli (Fig. 425, 6). They exhibit the apparent origin of the trifacial nerves.

The pons Varolii does not exist in Birds.

Fig. 425.



SUPERIOR VIEW OF THE ENCEPHALIC ISTHMUS.

1, 1, Corpora restiformia; 2, section of the middle cerebellar peduncle; 3, section of the posterior cerebellar peduncle; 4, anterior cerebellar peduncle; 5, floor of the posterior ventricle; 6, valve of Vieussens; 7, 7, tubercula testes; 8, 8, tubercula nates; 9, 9, thalami optici; 10, corpus geniculatum internum; 11, corpus geniculatum externum; 12, corpus striatum; 13, tænia semicircularis; 14, pineal gland; 15, its peduncle; 16, common anterior opening; 17, 17, anterior pillars of the trigonum or fornix; 18, trifacial nerve; 19, facial nerve; 20, auditory nerve; 21, glosso-pharyngeal nerve; 22, pneumogastric nerve; 23, spinal nerve.

3. The Crura Cerebri (Figs. 425, 426).

These are two very large white fasciculi, visible at the inferior surface and sides of the isthmus, covered superiorly by the corpora quadrigemina and thalami optici, and continuous—above the pons Varolii—with the fibres of the medulla oblongata; while their anterior extremities enter the cerebral hemispheres.

These peduncles are separated from each other by a middle fissure—the *interpeduncular*—which bifurcates in front to circumscribe the *pisiform tubercle* (*corpus albicans, bulbi fornicis*)—a small, single, and rounded elevation of a white colour like the peduncles, covered by the pituitary gland (Fig. 423, 4), the root of which is represented by the tuber cinereum, and which is situated in front of this body (see *Description of the pituitary gland* on p. 773).[1]

Behind, the crura cerebri are limited by the anterior border of the pons Varolii. In front, they are circumscribed by the optic nerves, which pass obliquely around their anterior extremity and join on the middle line before the tuber cireneum, to form a commissure called the *chiasma* (or *commissure*) *of the optic nerves* (Fig. 424, 8). On the sides, their tissue is confounded with that of the corpora quadrigemina and thalami optici, which are superposed on the crura cerebri. It may be remarked that the part of their lateral face situated below

[1] The inferior face of the crura cerebri offer some more interesting details. Thus, behind the corpus albicans is a triangular space—*the interpeduncular perforated layer* (*locus perforatus posticus, pons Tarini*) pierced by a large number of openings for the posterior group of arterioles given off from the circle of Willis. On each crus is seen, near the middle line, a longitudinal fissure from which issues the nerve of the third pair; outside this is another groove that separates a fasciculus of white fibres from a mammilated surface of a grey colour. There are also observed some fasciculi of transverse fibres which proceed from the band of Reil. The crura cerebri represent two stages, separated by a mass of grey substance named the ***locus niger.***

the tubercula testes, forms a well-defined triangular space, designated the *band of Reil, lateral triangular fasciculus*, and *lateral oblique fasciculus of the isthmus.*

4. The Crura Cerebelli.

The cerebellum is attached to the upper face of the isthmus, by two short and thick lateral funiculi of white substance, between which is comprised the posterior ventricle ; these constitute the *crura cerebelli.*

Three distinct fasciculi enter into the composition of each of these cords—an *anterior*, a *posterior*, and a *middle.*

The latter, or *middle cerebellar peduncle* (*crus cerebelli ad pontem*), is the largest of the three. It is formed by the prolongation of the extremities of the pons Varolii (Figs. 425, 2 ; 426, 6).

The *posterior cerebellar peduncle* (*crus ad medullam oblongatum*)—the most slender—is formed by the restiform body, one portion of which is reflected below the posterior root of the auditory nerve to reach the substance of the cerebellum. It is closely united to the preceding, from which it is with difficulty distinguished (Fig. 425, 3).

The *anterior cerebellar peduncle* (*processus e cerebello ad testes*) (Fig. 425, 4) is a fasciculus very distinct from the other two, related by its inner border to the middle peduncle, which it obliquely crosses, loses itself in the cerebellum by its supero-posterior extremity, arriving behind the testes, and passing beneath these small organs by its antero-inferior extremity, along with the band of Reil or supero-lateral fasciculus of the cerebral peduncles.

In studying the structure of the cerebellum, we will see how these peduncles comport themselves in its interior.

5. Valve of Vieussens (Fig. 425, 6).

This designation is given to a very thin, white layer which unites, on each side, the two anterior cerebellar peduncles. In shape it is nearly a parallelogram. Its *superior face* is covered by the cerebellum ; the inferior concurs in forming the roof of the cerebellar (*fourth*) ventricle. The two *lateral borders* are joined to the peduncles which this valve unites ; the *anterior* is attached behind the *testes* ; while the *posterior* adheres to the anterior vermiform process (*linguetta laminosa*) of the cerebellum.

Gall has considered this layer as a commissure of the anterior cerebellar peduncles, and we think rightly ; for we see it formed almost exclusively of transverse fibres which run from one of these peduncles to the other. These fibres are most apparent in front, where the membrane is much thicker ; behind, they are mixed with some longitudinal fasciculi.

6. Corpora Quadrigemina or Bigemina (Figs. 425, 7, 8 ; 426, 8, 9).

These are four round eminences, placed in pairs, which surmount the cerebral peduncles behind. The two posterior, the smallest, are also named the *tubercula testes*, and the anterior pair the *tubercula nates.*

The *posterior corpora quadrigemina*, or *tubercula testes*, are related, in front, to the anterior eminences ; behind, to the anterior cerebellar peduncles and the valve of Vieussens, from which they are separated by a transverse groove, at the bottom of which arise the pathetici nerves. An oblique band unites them, outwardly, to that portion of the optic layer named the *corpus geniculatum internum;* while they limit, externally, the bands of Reil.

The *anterior corpora quadrigemina*, or *tubercula nates*, are distinguished from the preceding not only by their larger volume, but by their colour, which is grey, that of the testes being white. They are also rounder, nearer each other, and covered by the cerebral hemispheres; while the posterior rather lie beneath the cerebellum. A curved groove isolates them, in front, from the thalami optici.

7. **Thalami Optici** (Fig. 425, 9).

This name is given to that part of the upper face of the isthmus which is situated in front of the corpora quadrigemina. These thalami are, therefore, placed above the anterior part of the cerebral peduncles.

Larger altogether than the corpora quadrigemina—and more so before than behind—each exhibits a grey, slightly convex, and very irregularly quadrilateral surface, covered by the velum interpositum, which separates it from the cornu Ammonis (*pes hippocampi*), and from the posterior pillars of the fornix, beneath which they are placed.

Inwardly, they incline towards each other in forming on the middle line a somewhat deep fissure, in which runs, from before to behind, two white longitudinal bands that will be noticed hereafter as the *anterior peduncles* of the pineal gland. This fissure enters, behind, the *common posterior opening* (*foramen commune posterius*); in front, into the *common anterior opening* (*foramen commune anterius*)—orifices which will be described with the interior of the isthmus.

Outwardly, each thalamus opticus shows two prominences called the *corpora geniculata*, from which arise the second pair of nerves; placed one before the other, the posterior nearer the middle line than the anterior, these two projections are distinguished as *external* and *internal*. The *corpus geniculatum externum* is always more voluminous, better defined, and situated on a more elevated plane than the *corpus geniculatum internum*, which is united to the posterior corpora quadrigemina by an oblique band (Figs. 425; 426, 10, 11).

Behind, the thalami optici appear to be notched to receive the nates, which they slightly enclose.

In *front*, they are separated from the corpus striatum by a groove, at the bottom of which is a narrow strip named the *semicircular band* (*tænia semicircularis*).

8. **Pineal Gland, or Conarium (Epiphysis Cerebri)**[1] (Fig. 425, 14).

This name has been given to a small tubercle of a reddish-brown colour, in the form of a pine-cone, enveloped by a duplicature of pia mater from the velum interpositum, with its apex upwards, and its base resting on the common posterior opening (~~*foramen of Monro*~~), which it closes, and around which it is attached by a circular ridge.

From this lamella is detached, in front, two fibrous cords—the *anterior peduncles* of the conarium (or *habenæ*). These (Fig. 425, 15) are two narrow

[1] This organ, and the next to be described, do not really belong to the isthmus system, but rather—as has been already mentioned—to the appended glands which should receive separate description. The first is probably the vestige of a rudimentary eye, the second that of a lymphatic gland. (It appears to be now conclusively established that the pineal body is the representative of an ancestral form of eye—most clearly demonstrated in certain lizards.)

white bands, which commence at the base of the pineal gland, and are directed forward parallel to each other, in the bottom of the fissure of the thalami optici, to which they firmly adhere. On arriving at the anterior common opening, they become attached to the anterior pillars of the crura of the fornix. Sometimes they are very narrow, and separated by an interval; but more frequently they are relatively wide, and immediately in contact on the median line.

The conarium is far from always offering the same volume; it has been shown in its usual dimensions in Fig. 425, and in Fig. 429 it is shown as incomparably larger.

The tissue of the pineal gland is greyish in colour, and contains more or less numerous calcareous granules. In the midst of its connective tissue are vesicles

Fig. 426.

LATERAL VIEW OF THE ISTHMUS.

1, Medulla oblongata; 2, corpus rectiforme; 3, lateral fasciculi of the medulla oblongata; 4, inferior fasciculus, or corpus pyramidale; 5, pons Varolii; 6, middle peduncle of the cerebellum; 7, cerebral peduncle (crus cerebri); 8, testis; 9, natis; 10, corpus geniculatum internum; 11, corpus geniculatum externum; 12, optic nerve; 13, fourth nerve resting on the band of Reil; 14, sensitive root of the trigeminal nerve; 15, its motor root; 16, facial nerve; 17, auditory nerve.

filled with polyhedral cells; it is in the centre of these vesicles that are found—in old animals—mineral concretions (brain sand—*acervulus cerebri*). Many anatomists consider this body a vascular gland; while others regard it as a nervous organ, which has relations with the brain through the medium of its anterior peduncles.

9. **Pituitary Gland** (Figs. 424, 11; 429, 19).

The *pituitary gland*—also named the *hypophysis cerebri* and *supra-sphenoidal appendage*—is a small disc-shaped tubercle, fixed to the anterior extremity of the interpeduncular fissure by the *pituitary stem* (*infundibulum*) and the *tuber cinereum*.

a. The *tuber cinereum* is a little eminence of a grey colour, situated in the middle line, between the corpus albicans and the chiasma of the optic nerves, at the anterior limit of the isthmus. This eminence is hollow, and its cavity is nothing more than a diverticulum of the middle ventricle.

b. The *infundibulum* is only a short conical prolongation, with its base attached to the tuber cinereum, and its apex to the superior face of the pituitary gland. The cavity of the tuber cinereum is continued into the infundibulum, and terminates in a *cul-de-sac* towards its summit. This prolongation, also formed of grey substance, is distinguished by its great fragility; so that it requires some care to preserve it intact when opening the cranium at its base.

c. The *pituitary gland* is lodged in the sella Turcica, where it is enveloped by the supra-sphenoidal duplicature of dura mater. It is a small, nearly circular body, flattened above and below, and more or less thick, according to the subjects.

Its *inferior face* rests on the sphenoid bone through the medium of the dura mater, to which it is strongly adherent; the *superior* covers the corpus albicans, with a portion of the cerebral peduncles, and in front receives the insertion of the pituitary stem. Its *circumference* is related to the supra-sphenoidal duplicature, the interior of which forms the cavernous sinus.

There is no cavity in the pituitary gland.

The matter composing it is yellow in the anterior half of the organ, and brown in its posterior portion. Its structure resembles that of the supra-renal capsules, and there is a tendency to regard it as a lymphatic organ (though it has been surmised that it may have a fuuction in connection with the blood-supply to the brain).

Internal Conformation of the Isthmus (Figs. 427, 428).

The isthmus is hollowed at the thalami optici by a central cavity, named the *middle* (or *third*) *ventricle*, which is extended backwards beneath the corpora quadrigemina by a canal—the *aqueduct of Sylvius;* this opens, below the valve of Vieussens, into the *posterior* (or *fourth*) *ventricle*—another cavity comprised between the cerebellum and medulla oblongata. These three diverticuli will be studied in succession.

1. Third or Middle Ventricle, or Ventricle of the Thalami Optici (Fig. 429, 13).

The *middle ventricle* is an irregular cavity, elongated from behind to before, depressed on each side, and offering for study two *walls*, a *floor*, a *roof*, and two *extremities.*

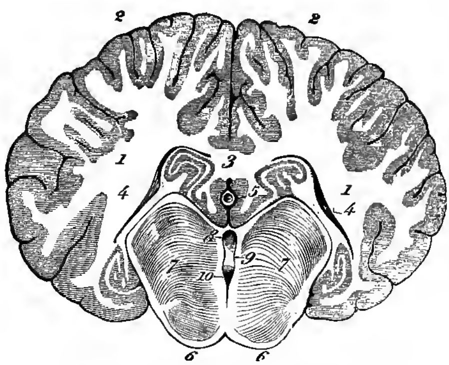
The two *walls* are smooth, nearly plane, or very slightly concave from above to below.

The *floor* is extremely narrow, and only forms a channel, the bottom of which corresponds to the interpeduncular fissure—which is nearer in front than behind—and to the corpus albicans and tuber cinereum. The cavity of the latter (Fig. 429, 20), prolonged into the pituitary stem, communicates with the middle ventricle, and assists in its formation.

The *roof*, as narrow as the floor, and, like it, nothing but a channel, is constituted by the two thalami optici, which are joined to one another above the ventricle, forming a thick grey commissure (Fig. 429, 16). It is terminated at its extremities by the two orifices already noted as the *posterior* and *anterior common foramina.* The *posterior common foramen* (Fig. 429, 15) commences behind the grey commissure, and terminates at the base of the pineal gland by an irregularly expanded *cul-de-sac.* It is limited behind by the *posterior white* *commissure*—a thin fasciculus of transverse fibres placed in advance of the corpora quadrigemina, above the entrance to the aqueduct of Sylvius (or *iter a tertio ad quartum ventriculum*), the extremities of which are lost in the substance of the thalami optici (Fig. 427, 9). The *anterior common foramen*, also designated the *foramen of Monro* (and *iter ad infundibulum*) (Fig. 429, 14), is the medium of communication between the middle and lateral ventricles, and affords a passage to the vascular cord which unites the two choroid plexuses. It is pierced in front of the grey commissure, beneath the summit of the fornix, the two pillars of which concur to circumscribe it, and between which is seen the *anterior white commissure*. This is a small band of white transverse fibres, analogous to that which constitutes the posterior commissure, but thicker, and passing in front of the anterior pillars of the fornix, its extremities entering and becoming lost in the corpus striatum on each side.

The *posterior extremity* of the middle ventricle—narrower than the anterior, and placed on a more elevated plane—is continuous with the aqueduct of Sylvius, the entrance of which (Fig. 427, 10) is beneath the posterior commissure, towards the common foramen.

Fig. 427.



TRANSVERSE SECTION OF THE BRAIN AT THE POSTERIOR COMMON FORAMEN.

1, White substance of the hemisphere, or centrum ovale of Vieussens; 2, 2, grey substance forming the external layer of the convolutions; 3, section of the corpus callosum; 4, 4, interior of the lateral ventricles; 5, section of the great vena Galeni; 6, 6, cerebral peduncles; 7, 7, section of the isthmus; 8, posterior common foramen; 9, posterior white commissure; 10, entrance to the aqueduct of Sylvius.

The *anterior extremity*, more dilated than the posterior, is situated immediately above the optic chiasma, and is only separated from the bottom of the great interlobular fissure of the brain by a small and very thin grey lamina attached to that chiasma, and for this reason named by writers the *grey root of the optic nerves*. This lamina (*lamina cinerea*) is readily seen when the optic commissure is turned back on the pituitary gland; it is sufficient to traverse this to enter the middle ventricle.

The *ependymis*, which forms the wall of the central canal of the spinal cord, also lines the walls of this cavity; through the aqueduct of Sylvius, it is prolonged into the posterior (or fourth) ventricle; by the foramen of Monro it passes into the lateral ventricles, and thence into the spaces in the middle of the olfactory lobes.

2. **Aqueduct of Sylvius** (Fig. 429, 6).

This is a longitudinal median canal, passing beneath the corpora quadrigemina, and above the crura cerebri.

It is prismatic in shape; its anterior extremity communicates with the middle ventricle, and the posterior opens below the valve of Vieussens into the fourth ventricle.

3. The Posterior or Cerebellar Ventricle (Fig. 429, 5).

This ventricle[1] (or *sinus rhomboidalis*), situated beneath the cerebullum, between its peduncles, and above the medulla oblongata and pons Varolii, is a cavity elongated from before to behind, and almost entirely occupied by the vermiform processes.

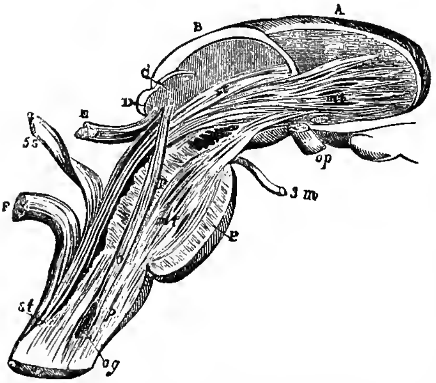
Its *superior wall* is formed by these two processes, the valve of Vieussens, and that of Renault. The *inferior*, or *floor* of the cavity, is represented by the depression on the upper face of the medulla oblongata, and which is prolonged in front, above the pons Varolii, to near the testes.[2]

The *anterior extremity* communicates with the aqueduct of Sylvius. The *posterior* occupies the summit of the calamus scriptorius.

Structure of the Isthmus.

The isthmus, being only a prolongation of the spinal cord, ought to resemble it in its structure; and this is, in fact, what is observed, particularly in its posterior part, the common features in their organization, however, disappearing as we approach its anterior extremity.

Fig. 428.



DISSECTION OF THE MEDULLA OBLONGATA, SHOWING THE CONNECTION OF ITS SEVERAL FASCICULI, OR STRANDS.

A, Corpus striatum; B, thalamus opticus; C, D, corpora quadrigemina; E, commissure connecting them with the cerebellum; F, corpora restiformia; P, P, pons Varolii; *st. st*, sensory tract; *mt*, *mt*, motor tract; *g*, olivary tract; *p*, pyramidal tract; *og*, olivary ganglion; *op*, optic nerve; *3m*, root of third pair (motor); *5s*, sensory root of the fifth pair.

We will follow the distribution of the *white* and *grey substance* in the isthmus.

The white substance includes the *longitudinal white fibres*, as well as the *transverse white fibres*. Among the first may be mentioned the *infero-lateral columns*. These decussate at the neck of the medulla oblongata, in successive layers; afterwards they pass along the inferior middle fissure, where they constitute the *motor portion of the pyramids of the medulla oblongata*, and, traversing the pons Varolii, they then form the upper stage of the crura cerebri, finally entering the corpora striata.

The posterior columns also decussate a little in front of the antero-lateral columns. When this intercrossing of fibres has terminated, they form the *deep* or *sensitive portion of the pyramids*, pass beyond the pons Varolii, constitute the upper stage of the crura cerebri, and pass into the substance of the thalami optici.

With regard to the inferior columns of the spinal cord, they do not decussate on entering the isthmus, but they are displaced by the infero-lateral. We then find them in the centre of the medulla, beneath the grey substance in the floor of

[1] As the cerebellum concurs in the formation of this cavity, it would perhaps be better to defer its study until that organ has been described.

[2] For the features of this region, see the description of the upper face of the medulla oblongata.

the fourth ventricle. After passing through the pons Varolii and the upper stage of the crura cerebri, they enter the thalami optici.

To the longitudinal fibres which continue those of the spinal cord, must be added the fibres of the *corpora restiformia* and those of the *anterior cerebellar peduncles*.

The *corpora restiformia* proceed from the cerebellum, of which they form the posterior peduncles, and go to be lost on the surface or in the mass of the medulla oblongata, under the surface of the white transverse *tractus*.

The *anterior cerebellar peduncles* descend from the cerebellum, approach the middle line, concur in the formation of the upper stage of the crura cerebri, and terminate in the thalami optici.

To this important system of *white longitudinal fibres*—a prolongation of those of the spinal cord—are found annexed as complimentary elements in the organization of the isthmus, several systems of transverse fibres and masses of grey substance. The following is a summary account of the arrangement of these new elements.

In proceeding from behind to before, we notice, among the *white transverse fibres*—

1. The expansion of arciform fibres which sometimes covers the inferior face of the medulla oblongata (Fig. 456, *j*): their superior extremity is lost on the corpus restiforme; the inferior passes into the intermediate fissure of the pyramid and the lateral fasciculus. It is derived from the column of Göll (Féré).

2. The proper fibres of the pons Varolii: they constitute a very thick semicircular fasciculus, the extremities of which form the middle cerebellar peduncles and enter the cerebellum. A portion of this fasciculus envelops, inferiorly and laterally, the longitudinal fibres of the isthmus; the other passes between the two portions of the anterior pyramids.

3. The transverse fibres of the valve of Vieussens and those of the white commissure, which have been already noticed.

The *grey substance* of the isthmus, which now remains to be mentioned, is far from being so abundant as the white substance, and—as in the spinal cord—it is principally situated deeply in the substance of the organ—at least in the greater number of points.

If the grey matter of the cord is traced into the medulla oblongata, it will be found that it undergoes modifications in its distribution, with regard to the course and displacement of the columns of fibres. The *inferior cornua* are divided into two portions, in consequence of the decussation of the infra-lateral columns. Their bases are spread along the middle fissure on the floor of the fourth ventricle, where they form the *nuclei of the cranial motor nerves*. The heads, carried backwards and outwards, constitute the *motor nuclei of the mixed cranial nerves*. The *superior cornua* are also divided into two portions on entering the medulla oblongata, by the decussation of the superior columns. The *base*, which accompanies the central canal of the spinal cord, is spread on the floor of the fourth ventricle, and forms—to the outer side of the nuclei of the motor nerves—the grey mass known as the *sensitive nuclei of the mixed cranial nerves*. The *head* is abruptly thrown outwards, and constitutes the *sensitive nucleus*—the origin of the large branch of the trigemini.

To these grey formations must be added the masses alien to the spinal cord. We mention: the *pyramidal nuclei*, which occupy the inner border of the pyramids; the *olivary nuclei*, that are found in other than Soliped animals; the *small protuberential masses*, disseminated between the transverse fibres of this region; and the *locus niger*—a grey mass that separates the two stages of the crura cerebri. Finally, there is a small mass of this grey substance which constitutes each of the corpora quadrigemini, and which is covered by a thin pellicle of white matter, scarcely visible in the anterior eminences.

The *thalami optici* is a similar mass, though more voluminous, darker coloured, and without a layer of white substance on its superficial face.

Lastly, nerve-cells exist between the various layers of transverse fibres of the pons Varolii, and between the tubes which constitute the valve of Vieussens.

Differential Characters in the Isthmus of the other Animals.

Apart from its volume, the isthmus does not present any sensible differences in **Ruminants** and the **Pig.** In the **Ox,** it is remarked that: 1. The *inferior pyramids of the medulla oblongata* are more prominent, and the transverse cords parallel to the pons Varolii more voluminous than in Solipeds. 2. The *crura cerebri* are short. 3. The *optic nerves* are larger than in Solipeds. 4. There is a large developed *pituitary gland*, excavated by a wide cavity, and flattened above and below. 5. Lastly, the *testes* are more conical, and less distinct from the *nates* than in the animals already studied.

In the **Carnivora,** the *fourth ventricle* is very wide and deep, and bordered by salient and detached *corpora restiformia.* Its floor is marked by some white transverse striæ, more apparent than in the Horse. The *pons Varolii* is large; the *columns* of the *medulla oblongata,* parallel to its posterior border, are as developed as in the Horse, without taking into consideration the differences in size of the two species. The *pyramids* are voluminous, and the *olivary bodies* well defined. The *testes* are larger than the *nates.*

As a general rule, the development of the pons Varolii is in relation to that of the lateral lobes of the cerebellum.

Comparison of the Isthmus of Man with that of Animals.

In human anatomy, the *medulla oblongata* and *isthmus* are described separately.

The first shows on its lower face a well-marked groove—a continuation of that of the spinal cord. It terminates anteriorly in a deep fossa, named the *foramen cæcum of Vicq-d'Azyr.* The *pyramids* are well marked. The *olivary bodies* are much more prominent than in animals, and are also distinguished by the presence of a grey nucleus in their interior. The medulla oblongata of Man has not the transverse band, behind the pons Varolii, which we have found in the Horse (Fig. 424).

With regard to the isthmus proper, it contains the parts in front of the medulla oblongata already studied in the domesticated animals. The *pons Varolii* is very large; the *crura cerebri* are separated from each other by a groove, at the bottom of which are several small openings. The *fourth ventricle* is deep, is bordered by well-developed *corpora restiformia,* and enclosed posteriorly and laterally by the *valves of Tarini* (*velum medullare posterius*). On its floor are remarked transverse striæ (*lineæ transversæ*) named the *barbs of the calamus scriptorius*, which are also found in the Dog. The *testes* are smaller than the *nates;* but the difference in their volume is less considerable than exists between Solipeds and Ruminants. Their structure is identical with that already described.

Article III.—The Cerebellum.

The *cerebellum,* or posterior enlargement of the brain—is the single mass supported by the isthmus, separated from the cerebrum by the transverse partition constituting the tentorium cerebelli, and lodged in the posterior compartment of the cranial cavity, which almost exactly gives the measure of its volume.

Leuret has ascertained the weight of this organ. On the average it weighs $2\frac{1}{4}$ ounces in the entire Horse and Mare, and $2\frac{3}{4}$ ounces in the castrated Horse. This weight is to that of the brain as 1 : 7·07 in Stallions; as 1 : 6·59 in Mares; and as 1 : 5·97 in Geldings.

1. External Conformation of the Cerebellum (Figs. 423, 433).

The cerebellum—isolated by dividing its lateral peduncles from the medulla oblongata on which it is fixed—is almost globular in form, slightly elliptical, and elongated transversely; while its external surface is furrowed by a great number of sulci, the two principal of which (*sulci horizontalis*) pass in a circular manner on each side of the middle line around the organ, dividing it into three *lobes*—a *middle* and two *lateral*.

The *three lobes* of the cerebellum are not always readily distinguished from each other, in consequence of the shallowness and irregularity of the two sulci separating them. We will, nevertheless, study them in succession, and afterwards examine—in a general manner—the furrows on their superficies.

Middle lobe (Fig. 423, c^1).—This has been compared to a silkworm rolled in a circular manner around the middle portion of the cerebellum, with its two extremities joined—without being confounded—below the inferior face of the organ.

This vermicular disposition is not well defined in the middle and superior portions of the cerebellum, where this lobe is always more or less subdivided into large multiple and irregular lobules; but it is better marked before and behind, in those points which correspond to the two extremities of the creature selected as a term of comparison. There may be remarked two longitudinal eminences transversely annulated on their surface, and curved beneath the cerebellum in such a way as to come in contact with each other. These eminences constitute the *anterior* and *posterior vermiform processes*. Their extremities are lodged in the fourth ventricle, the roof of which they concur in forming.

On the *anterior vermiform process* the posterior border of the valve of Vieussens is inserted.

The *posterior vermicular process* also receives the insertion of a valve already mentioned, and which must be again briefly referred to. This valve—described for the first time by Renault—forms a lamina of a certain thickness stretched above the calamus scriptorius. It has exactly the triangular form of this space, and presents a superior face covered by the posterior vermiform process; an inferior face, studded in some points with small vascular loops; a base fixed to the *vermis*, near the free extremity of that prominence, and to its lateral parts; two lateral borders, attached to the corpora restiformia on each side of the calamus scriptorius; and a summit corresponding to the receding angle of the excavation. This lamina is, doubtless, nothing more than a septum formed by the external pia mater, and on which is extended the internal membrane that lines the walls of the cerebellar ventricle. Otherwise, it is in direct continuity, towards its base, with an evident dependency of the pia mater—the *plexus choroides*.[1]

Lateral lobes (Fig. 423, c^2, c^2).—These are shaped like two irregular segments of a sphere. Their surface, fissured and lobulated in every direction, presents nothing interesting externally, superiorly, or posteriorly. It is by their inferior part that the peduncles enter the substance of the cerebellum; and behind this point, beneath their lateral parts, lies the *cerebellar plexus choroides*.

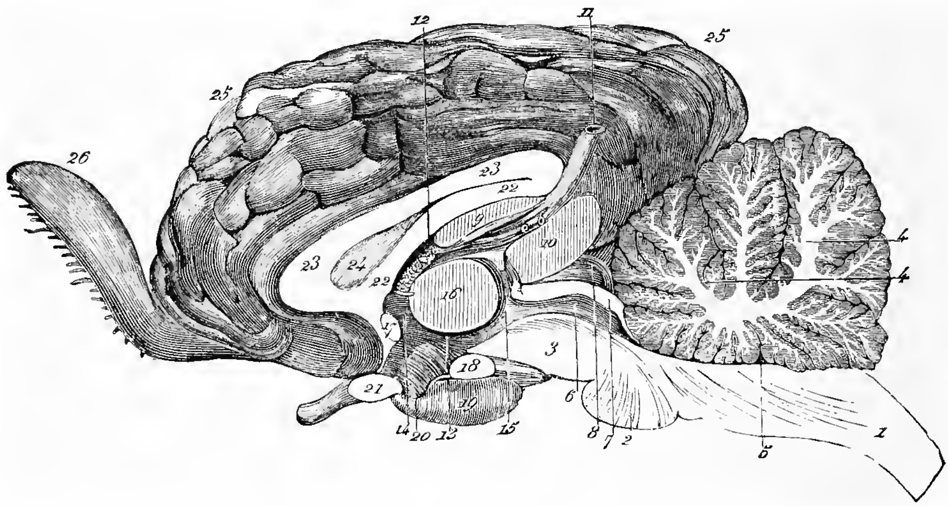
The *cerebellar choroid plexuses*.—This name is given to two small reddish granular masses, formed of vascular loops, elongated from before to behind,

[1] This septum is represented in the rudimentary state in Man, by the *valvulæ Tarini*.

flattened above and below, and comprised at their internal borders between the corpora restiformia and the inferior face of the lateral lobes of the cerebellum, to which they are strongly adherent by their superior face. These two plexuses are joined by means of Renault's valve, which is united to them towards its base.

Sulci and lobules of the cerebellum.—On examining, in a general manner, all the sulci which intersect the external surface of the cerebellum, we see that they penetrate to very unequal depths in the substance of the organ, and that they

Fig. 429.



MEDIAN AND VERTICAL SECTION OF THE BRAIN.

1, Section of the medulla oblongata; 2, ditto of the pons Varolii; ditto of the crura cerebri; 4, ditto of the cerebellum, showing the arbor vitæ; 5, posterior ventricle covered by the cerebellum; 6, aqueduct of Sylvius; 7, section of the valve of Vieussens (the figure and the line proceeding from it are too much forward); 8, natis; 9, internal extremity of the hippocampus; 10, section of the pineal gland (it is as voluminous as it was in the specimen from which this drawing was taken); 11, great vena Galeni, proceeding from the velum interpositum and choroid plexus, 12; 13, middle ventricle; 14, foramen of Monro; 15, common posterior foramen; 16, grey commissure; 17, anterior white commissure; 18, section of the corpus albicans; 19, ditto of the pituitary gland; 20, interior of the pituitary stem communicating with the middle ventricle; 21, section of the optic chiasma; 22, ditto of the fornix; 23, ditto of the corpus callosum; 24, septum lucidum; 25, cerebral convolutions; 26, olfactory lobule.

divide it into successively decreasing segments, of which Figs. 429 and 432 may furnish a sufficient idea.

There is at first a certain number of principal lobules, which are divided into secondary lobules; and these, again, are in their turn separated into short lamellæ, representing the extreme limits of cerebellar lobulation.

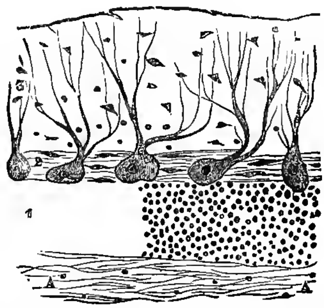
Leuret has counted 178 lamellæ in a section of the middle cerebellar lobe of the Horse. In this animal he found the largest number.

2. Internal Conformation and Structure of the Cerebellum.

The cerebellum concurs—by its inferior plane and the internal face of its peduncles—to form the cavity already described as the *posterior* or *cerebellar* *ventricle;* but in the mass of the organ itself there is no trace of excavation or other peculiarity. This is demonstrated in the most evident manner by sections of its substance made either in an antero-posterior or in a transverse direction. We only see in these, traces of the sulci which divide the organ into lobules; and they also afford evidence as to the structure of the cerebellum, showing that—like all the other parts of the cerebro-spinal axis—it is formed of *white* and *grey substance.*

The latter—spread over the entire surface of the organ—constitutes the cortical layer of the different segments of which it is composed. It is even prolonged into the convolutions, which increase the surface-extent of the cerebellum. In each lobule it may be resolved into superposed layers, parallel to the layer of white substance that forms the nucleus of the lobule; between these layers of grey substance is a very thin mass of white matter.

Fig. 430.



ARRANGEMENT OF THE LAYERS AND CELLS OF THE CENTRAL GREY MATTER OF THE CEREBELLUM.

A, White matter. 1, Granular or rust-coloured layer (*substantia ferruginea*); 2, layer of Purkinje's cells; 3, superficial amorphous layer.

The *white substance,* enveloped on every side by the grey, forms two thick nuclei occupying the centre of the lateral lobes, and which are united and confounded on the median line in the texture of the middle lobe.

These two nuclei—in continuity on each side with the cerebellar peduncles—are only their prolongations or intercerebellar portions. They send into the middle of each principal lobule a long and thick branch, which gives off smaller divisions that ramify in the secondary lobules, and from which escape a new series of ramuscules that enter the smallest segments; this gives to the cerebellum a beautiful arboreal aspect, justly designated by the older anatomists the *arbor vitæ* (see Figs. 429, 432, for representations of the *arbor vitæ cerebelli*).

In the interior of these nuclei a little in front, there sometimes exists a small, slightly grey streak; this is the trace of the *corpus rhomboideum* (or *corpus dentatum* of Man).

Stilling has noted two small grey nuclei, which are symmetrical, and are situated in the inferior layers of the middle lobe.

The nuclei of the white substance of the cerebellum are constituted by nerve-tubes, which are intermixed with numerous nuclei, and are continuous on one side with the crura cerebelli, and on the other terminate in the cells of the grey substance.

In the grey streak that forms the corpus rhomboideum, is a great number of large nerve-cells.

With regard to structure, the grey matter of the cerebellum is made up of three layers; the *superficial* is very rich in blood-vessels, has a greyish tint, and is composed of rounded elements, indeterminate in their nature, lying in an amorphous substance; the middle layer, is composed of Purkinje's cells—large elements disposed in a single row, and provided with ramifying prolongations which are at first directed to the preceding layer, and are then reflected downwards into the deep layer, where they are perhaps continuous with the axis-cylinder of the nerve-tubes of the white substance. The latter—also named the *rust-coloured*

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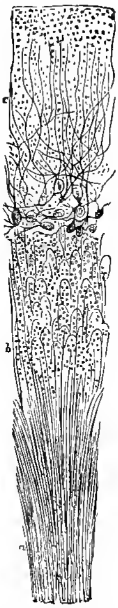
layer (*substantia ferruginea*)—has a yellow tint, and a mass of nuclei pressed against one another.

Fig. 431.



SECTION OF THE CORTICAL SUBSTANCE OF THE CEREBELLUM.

a, Medullary substance, showing its fibres; *b*, substantia ferruginea, composed of fibres and cell-nuclei; *c*, grey surface, granular at the surface, and containing large multipolar branching cells near the substantia ferruginea.

If the direction of the white substance fibres is traced, it will be found that some form an intra-cerebellar commissural system, while others constitute a radiation system that unite the cerebellum to the other parts of the brain. The first extend from one corpus rhomboideum to the other, across the cerebellum, or in following the middle cerebellar peduncles. The second represent the anterior and posterior cerebellar peduncles and a part of the middle peduncle. The anterior peduncles, after intercrossing, pass into the thalami optici (*red nuclei of Stilling*); the posterior enter the nuclei of the restiform bodies and olivary body, where they become united to the sensory system of the spinal cord; lastly, the middle ones, after intercrossing, disappear in the grey nuclei of the pons Varolii.

The prolongations of the large cells in the cortex cerebelli—also named the *cells of Purkinje*—are continuous with the fibres of the white substance.

Differential Characters in the Cerebellum of other than Soliped Animals.

The external and internal conformation of the cerebellum offers the closest analogies in the domesticated Mammalia. In all, its volume, compared with that of the other encephalic lobes, is not invariable. Thus, while the relation between the weight of the cerebellum and that of the brain of the Horse is as 1 to 7; in the Ox it is as 1 to 9; the Dog 1 to 8; the Cat 1 to 6; and the Sheep 1 to 3. The cerebellar cortical convolutions are less numerous than in the Horse. Leuret has found 175 lamellæ in the middle cerebellar lobe of the **Ox**, 77 in the **Sheep**, 66 in the **Cat**, and 32 in the **Rabbit**. These are the only differences to be noted.

Comparison of the Cerebellum of Man with that of Animals.

In Man, the encephalic mass being enormous, the cerebellum is absolutely more considerable in volume than in the larger domesticated animals; though, in proportion to the cerebral hemispheres, it is smaller than in the Ox, its relation to the latter lobes being as 1 to 8.

It is covered by the occipital lobes of the brain; is wider than it is long, and projects much beyond the medulla oblongata. It has three lobes; but these are only visible on its lower aspect; on the opposite face, the median lobe is depressed and concealed beneath the lateral lobes, which are so large that they have been named the *cerebellar hemispheres*. The fissure which separates these hemispheres is named the *great middle fissure of the cerebellum*; it lodges the falx cerebelli. The inferior vermis forms a free projection in which is the fourth ventricle; this is termed the *uvula of the cerebellum*. The uvula is connected at each side with the *valves of Tarini*—laminæ of nerve-substance lodged for the most part in the fourth ventricle, and hidden by the lower face of the cerebellar hemispheres. The latter constitute, on the sides of the medulla oblongata, two prominences situated one below the other, above the crura cerebelli; the first is designated the *amygdala* or *tonsil*, the second the *pneumogastric lobule* (or *flocculus*).

Article IV.—The Cerebrum.

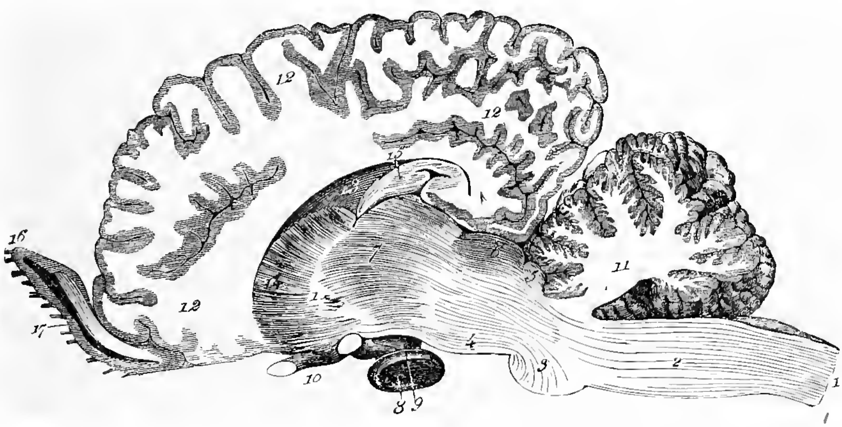
The *cerebrum*, the principal portion of the brain, comprises the two anterior lobes or *hemispheres* of that apparatus—enlargements which are elongated in the direction of the great diameter of the head and cranial cavity, lie beside each other in the middle line, and are united at their central part by a transverse commissure, and by the isthmus, the anterior extremity of which penetrates their substance inferiorly (see Figs. 424, 429, 432 for a good idea of this penetration).

These two lobes together represent an ovoid mass, having its larger extremity adjacent to the cerebellum; it is depressed above and below; deeply divided above, in front, and behind by a median antero-posterior fissure, and receives in the middle of its inferior face the insertion of the crura cerebri.

This mass—seven to nine times more voluminous than the cerebellum—fills the anterior compartment of the cranial cavity, and thus occupies the greater portion of that space.

Leuret has found that, on the average, it weighs in the Stallion, 15½ ounces; in the Mare, 14¼ ounces; and in the castrated Horse, 14 ounces 12¼ drams.

Fig. 432.



ANTERO-POSTERIOR AND VERTICAL SECTION OF THE BRAIN, TO ONE SIDE OF THE MEDIAN LINE.

1, 1, Isthmus; 2, medulla oblongata; 3, pons Varolii; 4, crus cerebri; 5, 6, corpora bigemina; 7, optic thalamus; 8, pituitary gland; 9, pituitary stem; 10, optic nerve; 11, cerebellum; 12, 12, cerebral hemisphere; 13, ventricle of the hemisphere; 14, corpus striatum; 15, cornu Ammonis; 16, olfactory bulb; 17, ventricle in the olfactory bulb.

It offers for study its *external conformation*, its *internal conformation*, and its *structure*.

External Conformation of the Cerebrum.

Instead of examining the organ in mass, with regard to its external conformation, we will first consider the *great longitudinal fissure* which divides it lengthways; and afterwards study its two lateral halves, or *cerebral hemispheres*, which in reality constitute two symmetrical organs.

1. **The Longitudinal Fissure** (Figs. 423, 424).

This fissure exists throughout the entire vertical and antero-posterior circumference of the cerebrum, but does not everywhere offer the same arrangement.

On the superior aspect of the organ it is very deep, and when the two hemispheres are separated to discover its extent, we see that it reaches to the upper face of the great commissure—the corpus callosum. Behind, it curves between the posterior lobes of the hemispheres, but without corresponding directly with the posterior, thick, rounded margin of the corpus callosum, above which there is a feeble adhesion between the two halves of the cerebrum, forming a kind of bridge. But in front it passes to the anterior margin of this commissure, and is prolonged in the interval between the anterior lobes of the hemispheres, to reach the inferior face of the brain.

Examined inferiorly, this interlobular fissure is well defined in front, where it reaches the anterior border of the corpus callosum ; but behind, on leaving the optic commissure—and which marks the anterior limit of the isthmus—this fissure appears suddenly to stop. This is because it becomes considerably enlarged, and is changed into a vast notch which admits the anterior extremity of the isthmus —or rather, it bifurcates to pass on each side between the hemisphere and the anterior extremity of the spinal prolongation, at first crossing the optic nerve, then turning round the crura cerebri and corpora bigemina, above which its branches unite, and are confounded with the undivided part of the fissure that separates the posterior lobes of the hemispheres (Fig. 424).

There exists, then, around the point of entrance of the isthmus into the cerebrum a well-marked line of demarcation, which constitutes—above and laterally—a very deep fissure, in which is embedded the vascular expansion known as the *velum interpositum ;* this space is designated the *fissure of Bichât*, or *great (transverse) cerebral fissure.*

The longitudinal fissure receives the longitudinal septum of the dura mater, or falx cerebri. It also lodges arteries and veins, among which it is necessary to distinguish the *great vena Galeni*, which ascends from the bottom of the fissure, after passing round the posterior border of the corpus callosum.

2. The Cerebral Hemispheres.

Preparation.—To see the fissures, sulci, and convolutions of the brain, the organ should be macerated for some days in a solution of nitric acid (5 or 10 to 100 of water). On removing it from this, the pia mater and vessels are carefully taken away and the brain gently dried, when the grooves and fissures widen, and the lobes and lobules can be distinctly seen.

Each hemisphere—or lateral moiety of the cerebrum—represents an ovoid segment, in which we may consider four *faces* and two *extremities.*

The *superior face* is convex, and is covered by the roof of the cranium, which is formed by the frontal and parietal bones.

The *external*—equally convex and insensibly confounded with the adjacent faces—corresponds to the lateral walls of this cavity—that is, with the squamous portion of the temporal bone, the parietal and frontal bones, and the ala of the sphenoid.

The *inferior*—irregularly mammillated—rests on the sphenoid bone. The *internal* is plane, and for the greater part of its extent is related to the other hemisphere through the medium of the falx cerebri ; it is in its central and inferior portion that the union of the two halves of the cerebrum takes place, by means of the great cerebral commissure and the anterior extremity of the isthmus.

The *posterior extremity* of the hemisphere corresponds to the cerebellum, which slightly depresses it, and from which it is separated by the transverse septum of the dura mater (*tentorium*).

The *anterior extremity*—or *lobe*—is lodged in the fossa formed on each side of the crista galli by the frontal and sphenoid bones.

The most important peculiarities to be noted on the surface of the hemispheres, are the convolutions, which we will now describe.

Cerebral Convolutions.[1]—These are the portions of the cerebral cortex which are disposed in the form of more or less sinuous ridges, separated from each other by deep grooves or fissures (*sulci*).

A convolution (or *gyrus*) may include several *plaits* or *folds*—that is, several parts separated or merely indicated by shallow grooves; so that *convolutions* should not be confounded with *plaits*.

The convolutions are not independent, strictly speaking, but are often united to those adjoining by more or less concealed reliefs, called *passage plaits* (*annectent* or *bridging gyri*); sometimes two or more are very ostensibly connected in this way.

The convolutions in Solipeds are very sinuous, and limited by deep sulci; some of these latter—more important than the others by their depth and constancy—are named *fissures*. Notwithstanding an apparent great irregularity, the cerebral convolutions are somewhat constant in their arrangement; so that it is possible to describe them one by one.

a. Fissure and grooves.—On the inferior face of the brain is seen a transverse depression at the optic commissure (Fig. 424, 10). This depression—named the *fissure* or *valley of Sylvius*—passes from within to without, and, on arriving at the side of the brain, divides into two or three branches, of which one—the principal—is inflected backwards, reaches the posterior extremity of the hemisphere, and forms the superior limit of a lobe named the *temporal* or *sphenoidal lobe* (Fig. 433, 7). The other one or two branches remain slightly buried in the middle part of the hemisphere; they lodge the divisions of the middle cerebral artery.

In glancing over the superior surface, there will be perceived a deep groove coming from the great longitudinal fissure, which it intersects at nearly a right angle. This groove—which Leuret has named the *crucial fissure* (Fig. 423, 12)—is surrounded by a more or less apparent convolution, designated the *sigmoid gyrus* (Fig. 423, 11). The crucial fissure divides the superior face of the hemisphere into two parts—the anterior belonging to the *frontal lobe*, the posterior to the *parieto-occipital lobe*.

On the external face of the hemisphere is seen a deep groove, which, commencing between the middle and posterior branch of the fissure of Sylvius, is directed upwards in a curve, the concavity of which is inferior, and ends in the vicinity of the crucial fissure (Fig. 433, 8, 8). This curved groove resembles the *fissure of Rolando*. If looked at in the other direction—from before to behind—it appears to bifurcate in its middle part, and the upper branch (*interparietal*

[1] Leuret believes that the cerebral convolutions of animals are arranged after a certain type (longitudinal type) essentially different from the human type. We think the difference is not so great as has been imagined; and it appears possible to discover in the brain of brutes if not the longitudino-transverse type, at least the tendency to this type observed in the human brain. In the description given above, the value of this assertion can be judged. We ought to state that our conclusions are based on the comparative examination of the brains of adults and fœtuses, on the distribution of the blood-vessels, and on the physiological experiments which enabled us to fix the position of the excitable zones of the cerebral cortex in the larger Quadrupeds.

fissure) passes back to disappear in the posterior extremity of the hemisphere (Fig. 423, 5). The fissure of Rolando separates the frontal from the parietal lobe, and the portion of the brain comprised between its bifurcation and the posterior branch of the fissure of Sylvius, forms a quadrilateral lobe (Figs. 423, 13 ; 433, 10), which resembles the *lobule of the curved plait* in the brain of Man.

Lastly, on the internal face of the hemispheres is found the inner portion of the frontal and parieto-occipital lobes, and a long convolution that accompanies the corpus callosum (Fig. 429), named the *callosal convolution*, or *crested convolution* (*gyrus fornicatus*), because of the notches on its upper border in Man. It is separated from the frontal and parieto-occipital lobes by a deep groove —the *calloso-marginal fissure*.

The crested convolution commences, in front, beneath the genu of the corpus callosum ; behind, it is inflected downwards, is continuous with the hippocampal convolution, and by some annectent gyri is in relation with the posterior extremity of the hemisphere.

In fine, a cursory examination of the surface of the hemispheres denotes the presence of some principal grooves limiting three lobes and a lobule ; these are the *frontal*, *parieto-occipital*, and *sphenoidal lobes*, and the lobule of the *curved plait*.[1]

We will now describe the convolutions of these lobes and lobule.

b. Frontal lobe.—This lobe presents three faces.

The inferior face (*orbital lobe*) is triangular (Fig. 424), and its base is occupied by the fissure of Sylvius, in front of which is remarked the extra-ventricular nucleus of the corpus striatum (Fig. 424, 12), which has a portion of its surface perforated by vascular openings—the *locus perforatus*. Near the summit it detaches the *olfactory* or *ethmoidal lobule* (Fig. 424, 15), which arises by two white-coloured roots that margin the extra-ventricular nucleus ; the *external* root (Fig. 424, 13) is continuous with the convolution that is prolonged on the temporal lobe ; the *internal* root (Fig. 424, 14), which is shorter, arises from the inner face of the hemisphere, in front of the optic commissure. This appendicular lobule is directed forwards, and terminates by an oval expansion—the *optic bulb* (Fig. 424, 16)—which extends beyond the anterior extremity of the brain to be lodged in the ethmoid fossa. The olfactory lobule has a cavity in its interior—a diverticulum of the lateral ventricle—and is received into a depression of the frontal lobe, named the *olfactory fissure*, that extends to the summit of the orbital lobule, and separates two convolutions, the internal of which is named the *gyrus rectus* (Fig. 424, 21).

The external face of the frontal lobe shows a great fissure almost parallel with that of Rolando, and between these two fissures is a long convolution that usually describes three curves (Figs. 423, 6, 6 ; 433, 11, 11) ; this limited convolution takes the place of the *ascending frontal convolution* in Man. In front, it is always united to the other frontal convolutions, and the fusion is more or less apparent.

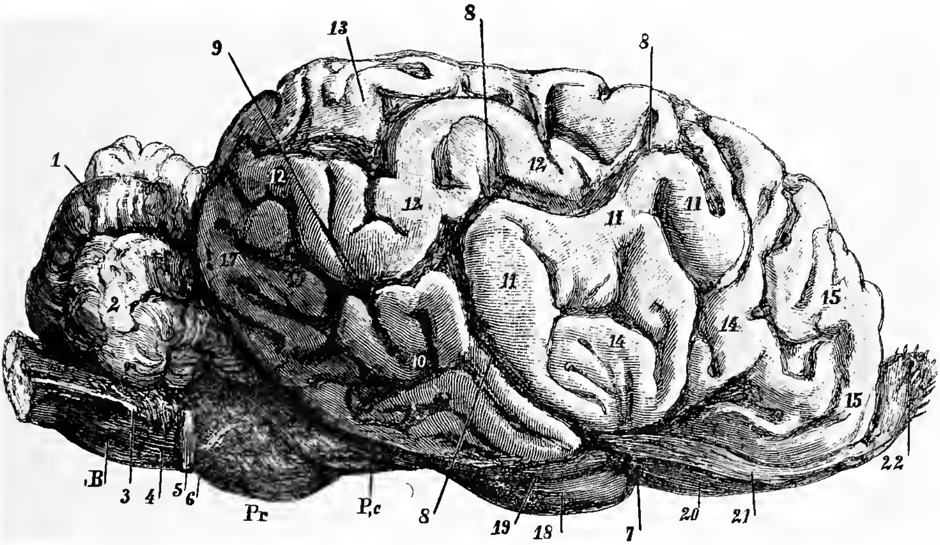
On the same face is perceived another great fissure, that commences in the vicinity of the crucial fissure, where it sometimes appears to be continuous with

[1] In the domestic animals, the occipital lobe—already so difficult to circumscribe in Man—is not more distinct in his neighbour. The posterior extremity of the hemispheres is, as it were, pushed forward by the internal occipital protuberance and the cerebellum. We make of the posterior region of the hemisphere a parieto-occipital lobe, implying by this term the fusion of the two parietal and occipital lobes. The latter is certainly very small, but we cannot admit its disappearance. We do not find in the brain of the Horse, the lobule of the *insula* or *island of Reil*, which in Man is concealed at the bottom of the fissure of Sylvius.

that of Rolando; it is directed forwards, outwards, and downwards—that is to say, it turns round the anterior extremity of the hemisphere to terminate near the fissure of Sylvius. Within this fissure is a triangular convolution, with its summit directed backwards; it is generally divided into two folds at its inferior part—this is the first frontal convolution (Figs. 423, 9; 433, 15, 15).

Another convolution is included between this fissure and that which margins the ascending frontal convolution; it is doubled into two wide flexuous folds which pass into the latter in front, and represents the second frontal convolution (Figs. 423, 10, 10; 433, 14, 14).

Fig. 433.



BRAIN OF THE HORSE (LATERAL FACE).

B, Medulla oblongata; Pr, pons Varolii; Pc, cerebral peduncle (*crus cerebri*). 1, Middle lobe of the cerebellum; 2, lateral lobe of ditto; 3, medullary root of the spinal accessory nerve; 4, internal roots of ditto and roots of the pneumogastric; 5, transverse fasciculus of the medulla oblongata, at the extremity of which the facial nerve appears to arise; 7, fissure of Sylvius; 8, 8, 8, fissure of Rolando; 9, posterior branch of ditto; 10, lobule of the curved plait; 11, 11, 11, limiting frontal convolution; 12, 12, parieto-temporal convolution (analogous to the ascending parietal convolution); 13, secoud parieto-temporal convolution; 14, 14, the two principal folds of the second frontal convolution; 15, 15, folds of the first frontal convolution; 17, parieto-occipital lobe; 18, inferior temporal convolution (2nd and 3rd of Man); 19, superior temporal convolution (1st of man); 20, intra-ventricular nucleus of the corpus striatum; 21, external root of the olfactory lobule; 22, olfactory nerves.

The *third convolution* seen in Man is not defined in the Horse by an important fissure, and if it exists in this animal it is probably represented by the origin of the inferior fold of the second convolution, which is sometimes separated from the rest by a shallow sulcus.

The internal face of the frontal lobe shows the internal part of the first frontal convolution, and a portion of the *calloso-marginal fissure* and *crested convolution*.

c. Temporal or sphenoidal lobe.—Also named the *mastoid lobule* by Veterinary Anatomists, the temporal lobe in Solipeds is a large pyriform eminence occupying the posterior part of the inferior face of the hemisphere (Figs. 423, 18, 19 ; 433, 18, 19). It is curved on itself, the convexity being outwards, and its inner border is related to the crus cerebri. It concurs in forming the great longitudinal fissure, its large extremity being turned forwards and margins the fissure of Sylvius, while the posterior extremity disappears in the posterior lobe of the hemisphere.

The surface of the temporal lobe is almost smooth, and shows scarcely more than one slight fissure, parallel to the posterior branches of the fissure of Sylvius (Fig. 433). This fissure (the *parallel fissure*) terminates more or less directly behind, between the branches of a Λ convolution—the *curved plait.* The external branch of the latter is continuous with the *superior temporal convolution* (Fig. 433, 19), which is comprised between the parallel fissure and the fissure of Sylvius. The part situated below the parallel fissure (Fig. 433, 18) represents the *second* and *third temporal convolutions* of Man. The temporal lobe is very simple in Solipeds, and is hollowed internally by a *cul-de-sac* cavity that constitutes the bottom of the posterior or reflected portion of the lateral ventricles.

d. Lobule of the curved plait.—Nearly quadrilateral in shape (Figs. 423, 13 ; 433, 10), this lobule is included between the fissure of Sylvius, the inferior part of the fissure of Rolando, and the interparietal fissure. It is formed by a large convolution, confounded at its commencement with the ascending frontal convolution, and which soon divides into two undulating plaits that unite, behind, with the superior temporal convolution, the curved plait, and sometimes with the convolutions of the parieto-occipital lobe.

e. Parieto-occipital lobe.—The limits of the occipital lobe—so difficult to establish in the human brain—cannot be determined in that of the Horse; for this reason it is that we now describe a parieto-occipital lobe resulting from the fusion of the parietal with the occipital lobe.

This lobe offers three faces. The external face is almost entirely occupied by a large convolution—the *parieto-temporal*—formed by two folds, the outer of which (Figs. 323, 7, 7 ; 433, 12, 12) margins the interparietal fissure and the anterior part of the fissure of Rolando ; in front, it is continuous with the plait that surrounds the crucial fissure and—through the medium of the latter—the first frontal convolution ; behind, it is inflected downwards to be continued on the posterior face of the lobe.

The internal face shows the parieto-occipital portion of the corpus callosum convolution, and of the *second parieto-occipital convolution ;* these two being separated by the calloso-marginal fissure, from which is detached a branch that rides on the superior border of the hemisphere and forms the crucial fissure.

The second parieto-occipital convolution (Figs. 423, 8, 8 ; 433, 13) has the form of a wedge, the summit of which is directed forward ; here it is single, and is confounded with the first convolution of the same lobe, and with the plait that surrounds the crucial fissure ; but it afterwards divides into two principal, almost straight plaits, which are continued on the posterior face of the lobe.

The latter is occupied by the posterior extremity of the parieto-occipital convolutions. It is oblique downwards and forwards, and is separated from the cerebellum by the transverse duplicature of the dura mater. On this face are seen three or four undulating plaits which join each other, and pass on to the convolutions of the hippocampus.

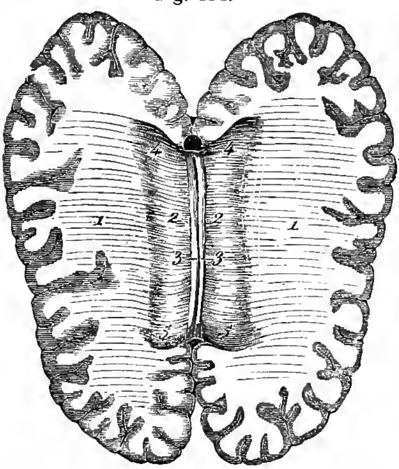
Internal Conformation of the Brain.

In separating the cerebral hemispheres by their upper face, we discover the great commissure known as the *corpus callosum*—the first object that presents itself for study in the internal conformation of the brain.

If we afterwards remove, with a sharp instrument, and by a horizontal section, all that portion of the hemispheres which covers this commissure, and also if the latter be excised to a certain extent to the right and left of the middle line, we shall penetrate two symmetrically disposed cavities in the centre of each hemisphere. These cavities are the *lateral* or *cerebral ventricles.*

They are separated on the middle plane by a thin partition—the *septum lucidum*—which is attached to the corpus callosum by its upper border, and fixed by its inferior border into the *fornix*, a kind of middle arch, beneath which is the *foramen of Monro*, or orifice communicating with the two ventricles. On the floor of these cavities is observed two large eminences—the *corpus striatum*

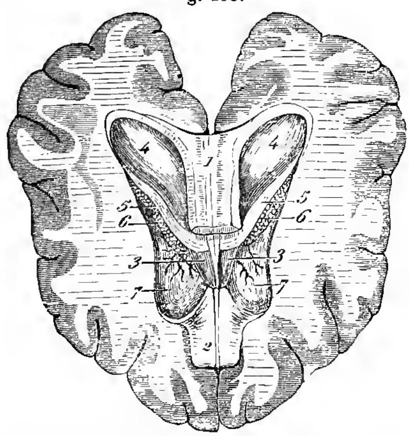
Fig. 434.



THE CORPUS CALLOSUM OF THE HORSE, AFTER REMOVAL OF THE UPPER PORTION OF THE CEREBRAL HEMISPHERES.

1, Centrum ovale of Vicq-d'Azyr; 2, 2, transverse fibres of the corpus callosum; 3, 3, tractus longitudinales; 4, 4, cornua, or angles of the posterior extremity; 5, 5, ditto of anterior extremity.

Fig. 435.



ANTERIOR PORTION OF THE LATERAL VENTRICLES OF THE DOG, EXPOSED BY REMOVAL OF THE ROOF.

1, Corpus callosum; 2, anterior part of the corpus callosum, turned forward after destroying the septum lucidum, to show the fornix, 3, 3; 4, 4, hippocampi; 5, 5, tæniæ semicircularis; 6, 6, choroid plexus; 7, 7, corpora striata.

and the *hippocampus;* with a vascular and apparently granular cord forming the *cerebral choroid plexus*—a dependency of the *velum interpositum.*

It now remains to enter into some detail with regard to the anatomical characteristics of all these parts.

1. **The Corpus Callosum** (Figs. 434, 435).

The *corpus callosum* is a kind of arch thrown over the two lateral ventricles, while at the same time it is a commissure uniting the two hemispheres. It belongs exclusively to Mammalia.

Composed entirely of white substance, this arch is of an elongated, quadrilateral shape, being elongated in an antero-posterior direction; it thus presents for study two *faces*, two *borders*, and two *extremities.*

The *superior face*, free in the middle, and corresponding to the bottom of the interlobular fissure, is covered right and left by the substance of the hemispheres. It is traversed from before to behind by two white, and generally very delicate, cords—the *tractus longitudinalis* (the *chordæ longitudinalis* of Lancisi) of the corpus callosum—which lie together on the middle line. The *inferior face* is divided—by the insertion of the septum lucidum—into two lateral portions, each of which forms the roof of one of the cerebral ventricles. Behind, it rests on the middle part of the fornix.

The two *lateral borders* of the corpus callosum disappear in the central substance of the hemispheres, where it is almost impossible to distinguish their limits.

The *posterior extremity* appears at the bottom of the interlobular fissure—after destroying the adhesion usually established above it between the two hemispheres—in the form of a thick, rounded enlargement (*splenium*) doubled below, and confounded with the middle part of the fornix. It is prolonged, laterally, above the ventricular cavities, in forming two angles (*lineæ transversæ*) which are soon lost in the white central substance of the cerebrum.

The *anterior extremity* comports itself in a similar manner between the anterior lobes of the hemispheres. It is named the *genu of the corpus callosum*, and is doubled more abruptly than the posterior end, terminating by a thin narrow portion—the *rostrum*.

2. The Lateral or Cerebral Ventricles (Figs. 429, 435).

The *lateral ventricles* are two large elongated cavities excavated in the hemispheres, lying against each other in their anterior moiety, and divergent in their posterior part, which is very much curved backwards, outwards, and downwards, to open into the substance of the sphenoidal lobe.

This disposition permits the division of the cerebral ventricles into two regions—an *anterior*, and a *posterior* or *reflected*.

The *anterior region—anterior cornu*, or *frontal diverticulum*—is separated in the median plane from the opposite ventricle, by the septum lucidum and the summit of the fornix, beneath which is the foramen of Monro establishing a communication between the middle and the two lateral ventricles, and between these latter. Above, it offers a smooth wall formed by the corpus callosum. Below, on its floor, there is first remarked, in front, the corpus striatum ; behind, the internal portion of the hippocampus ; in the middle, an oblique groove running backwards and inwards, at the bottom of which floats the choroid plexus. The anterior extremity of this region, occupied by the base of the corpus striatum, is continued by a narrow opening into the interior of the olfactory lobe. The posterior is prolonged, without any line of demarcation, by the *reflected portion* of the ventricular cavity.

The latter region (*posterior* or *descending cornu*, or *sphenoidal diverticulum*) occupies the most declivitous portion of the posterior lobe of the hemisphere, and is a much-curved canal with its concavity forward ; this canal terminates in a *cul-de-sac* in the substance of the sphenoidal lobe. On the floor of this canal is marked the posterior portion of the hippocampus and the choroid plexus.

A very fine membrane—the *ventricular arachnoid*—plays the part of a serous membrane and covers the walls of these cavities, being spread everywhere over a layer of white substance, prolonged into the ethmoidal diverticulum, and continuous, through the foramen of Monro, with that of the middle ventricle. This membrane secretes a limpid and transparent fluid, analogous to the cerebro-spinal fluid, though in health it is always in small quantity.

3. **The Septum Lucidum** (Fig. 429, 24).

This appellation is given to a thin middle band, standing vertically between the two lateral ventricles, elongated from before to behind, widened considerably at its anterior extremity, terminating in a point at its posterior extremity, and inserted above into the corpus callosum, below into the back of the fornix.

On the faces of this partition, which is formed of white substance, is spread the proper membrane of the lateral ventricles. In the human species, a narrow ventricle has been described as found in its substance ; but this does not appear to exist in the domesticated animals.

4. **The Fornix, or Trigonum** (Fig. 435, 3).

Also named the *vault of three* or *four pillars*, the fornix (*arch*) is a single middle body in the interior of the brain, concurring to separate the two ventricles, and serving to support the septum lucidum. It is depressed below and above, and is of a triangular form ; its apex, looking downward, stands in the median plane above the foramen of Monro and the thalami optici, though separated from the latter by the velum interpositum and the hippocampi, and receives on its upper face the insertion of the septum lucidum. Behind, at its base, and in the middle line, the fornix is confounded with the corpus callosum, which it supports ; it is prolonged on each side by a lamina extending to the surface of the hippocampus, forming the cortical layer of this deep convolution of the brain, and with its congener constituting the *posterior pillars* (*posterior crura, tæniæ hippocampi*, or *corpora fimbriata*) *of the fornix*. These two pillars are united by some white transverse fibres, which form what has been named the *lyre*.

In front, at its apex, the fornix is also attached to the corpus callosum, and divides into two cords or *anterior pillars* (*crura*)—(Figs. 425 ; 429, 17), which pass in front of the anterior cerebral commissure, are inflected downwards and backwards, in traversing the optic thalamus, on the sides of the middle ventricle, and finally have their extremities confounded with the mammillary process (*corpus albicans*).

These two crura limit, in front, the *foramen commune anterius*, or *foramen of Monro* (Fig. 425, 16), over which the apex of the fornix is thrown across like an arch (Fig. 425).

The fornix is white throughout its whole extent, with a greyish tint towards its summit.

5. **The Hippocampi** (Fig. 435, 4).

The *hippocampus*, or *cornu Ammonis* (from its resemblance to a ram's horn, the crest of Jupiter Ammon), is an elongated projection, a veritable internal convolution of the brain (is, in fact, the internal surface of the *gyrus fornicatus*, or convolution lying upon the corpus callosum, and which terminates at the fissure of Sylvius). It occupies the floor of the anterior part of the lateral ventricle, and is prolonged throughout its reflected portion, the curvature of which it exactly follows. Considered together, the two hippocampi somewhat closely resemble the uterine cornua of the Cow.

By their internal extremity, they are in contact with each other beneath the middle portion of the fornix, and above the optic thalamus, which is separated from them by the velum interpositum (Fig. 429, 9). Their external extremity occupies, in the sphenoidal lobe, the *cul-de-sac* of the reflected portion of the lateral ventricle.

The central mass of this projection is formed of a nucleus of grey substance, covered on both faces by a layer of white substance. The layer that covers its inferior face is named the *subiculum*, and that which extends over its surface is designated the *alveus*; it is a kind of prolongation of the posterior pillars of the fornix.

Towards the concave border of the hippocampus, this white layer offers a kind of wide hem, beneath which the choroid plexus passes; this hem constitutes a small curved band, like the cornu Ammonis, wider in its middle part than at its extremities, and is named the *corpus fimbriatum*, or *tænia hippocampus*.

The grey layer comprised between the two white bands also makes a slight projection at the inner border of the hippocampus, and forms the *fascia dentata*.[1]

6. The Corpora Striata (Fig. 435, 7).

The *corpus striatum* is a mass of grey matter interposed on the course of the crura cerebri. It includes the entire thickness of the floor of the lateral ventricle, and projects outwards, on the lower face of the hemisphere, between the two roots of the olfactory lobule.

The corpus striatum owes its name to its structure: the thick nucleus of grey matter composing it is, in fact, traversed by white fibres from the crura cerebri, which pass into the hemispheres; these fibres appear at several points in the form of sharply defined white striæ.

It is divided into two portions by these fibres, which collectively constitute the internal capsule (Fig. 436, CI). The external portion is the *extra-ventricular nucleus of the corpus striatum*, so named because of its position, and *lenticular nucleus*, in consequence of its shape; just as the internal portion is most frequently designated the *intra-ventricular nucleus of the corpus striatum*, or *caudate nucleus* (Fig. 436). The caudate or intra-ventricular nucleus occupies the anterior region of the lateral ventricle (Fig. 435, 7)

This eminence is pyriform in shape, and obliquely elongated forward and inward. Its surface is smooth, and regularly convex. Its base, or anterior extremity, corresponds to the anterior *cul-de-sac* of the ventricle. The summit, or posterior extremity, disappears at the commencement of the reflected portion of the ventricular cavity. Outwardly, the corpus striatum is limited by a groove that forms the angle of union between the floor and roof of the ventricle. Inwardly, it is separated from the optic thalamus and cornu Ammonis by another groove, in which the choroid plexus floats, and which is oblique inwards and forwards, and shows at the bottom the *tænia semicircularis* (Fig. 432, 13). This is a flattened white cord, which disappears inwardly towards the foramen of Monro, and bends outwards along the optic nerve to within about $\frac{3}{8}$ of an inch from the optic commissure; in this way it forms a kind of circular band around the anterior extremity of the isthmus, beneath which all the fibres of the latter pass to reach the cerebral hemispheres.

7. The Velum Interpositum and Choroid Plexus (Fig. 435, 6).

The *velum interpositum* (*velum vasculosum, tela choroidea*) is a vascular expansion derived from the pia mater, which penetrates the brain by the great

[1] Sabatier, taking comparative anatomy and embryology as his guide, regarded the hem of the hippocampus as a ganglion spread along the origin of the optic nerve.

transverse fissure, and insinuates itself between the thalamus opticus and the convolution of the cornu Ammonis. The velum, on arriving beneath the tænia hippocampus, terminates in the *choroid plexus*—a red, granular-looking cord, which is suspended by its antero-external border, and projects into the interior of the lateral ventricle.

The *choroid plexuses of the brain* (*plexus choroideæ*) extend from the anterior extremity of the corpus striatum to the bottom of the *cul-de-sac*, or sphenoidal diverticulum. In the anterior part of the ventricle, they occupy the oblique fissure which traverses that part, to the inner side of the caudate nucleus. In the posterior region, they float in front of the cornu Ammonis. Their anterior or internal extremity, more voluminous than the external, always forms a small appendage

Fig. 436.

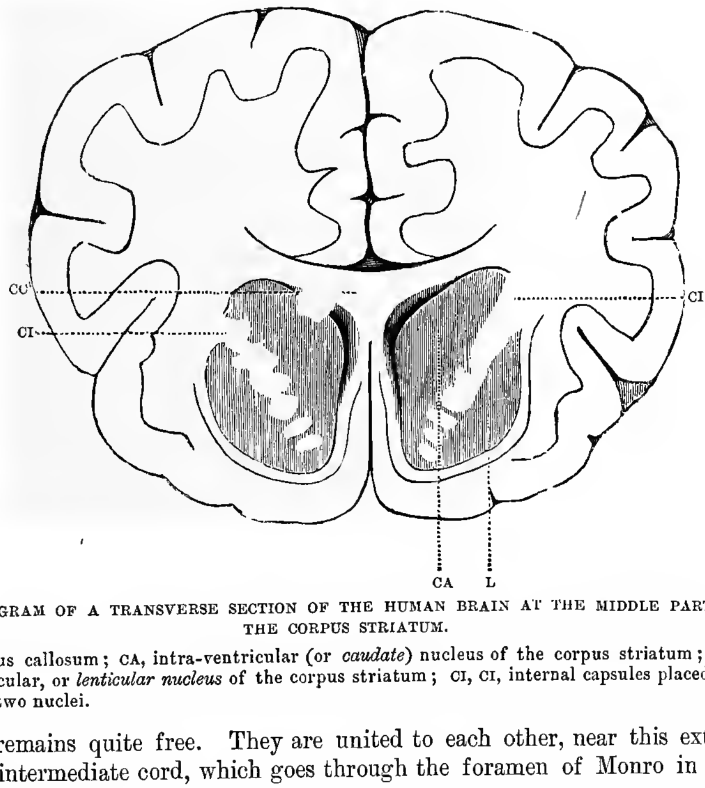


DIAGRAM OF A TRANSVERSE SECTION OF THE HUMAN BRAIN AT THE MIDDLE PART OF THE CORPUS STRIATUM.

CC, Corpus callosum; CA, intra-ventricular (or *caudate*) nucleus of the corpus striatum; L, extra-ventricular, or *lenticular nucleus* of the corpus striatum; CI, CI, internal capsules placed between these two nuclei.

which remains quite free. They are united to each other, near this extremity, by an intermediate cord, which goes through the foramen of Monro in passing beneath the fornix.

Like the velum interpositum, the choroid plexuses are formed by a network of arteries and veins. They are often incrusted in calcareous matter, and may be the seat of more or less voluminous cysts.

The veins proceeding from this vascular apparatus are very voluminous, and by their union form the great *vena Galeni*, which bends round the splenium of the corpus callosum to reach the interlobular fissure, and proceeds to the sinus of the falx cerebri.

The Structure of the Brain.

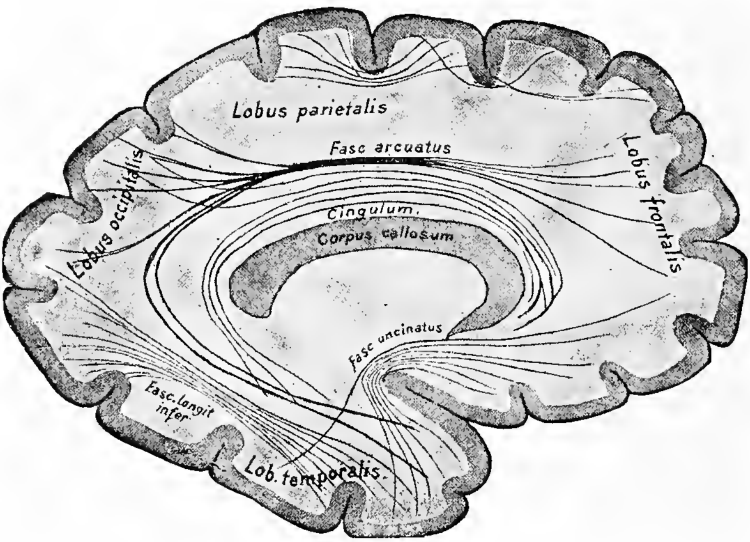
The structure of the brain is certainly one of the most interesting points in the study of the nerve-centres; for on a perfect knowledge of it depends the solution of the most difficult problems in the physiology of the nervous system. Numerous attempts have been made to elucidate its intimate organization; but we must here omit the multitude of secondary details revealed by these researches, and limit ourselves to the essential and fundamental facts.

The *two nerve-substances* enter into the texture of the cerebral hemispheres, and both are exactly disposed as in the cerebellum. .

The *grey substance* extends over the entire external surface of the brain, and is prolonged into the plaits—thereby augmenting the extent of that surface, and so forming the cortical layer of the cerebral convolutions. Gratiolet has compared this layer to a ring-purse opening on the internal face of the hemisphere, having for its rings the convolutions of the hippocampus and corpus callosum, in which is included the white medullary substance.

The grey matter projects into the lower face of the olfactory lobes and

Fig. 437



COURSE OF ONE PORTION OF THE ASSOCIATION NERVE-FIBRES IN A HEMISPHERE. (DIAGRAMMATIC.)

interior of the hemispheres, where it forms the central ganglia known as the *claustrum*, lenticular nucleus, and caudate nucleus.

In order to study the distribution of the central grey masses, horizontal and vertical sections must be made of the brain, through the corpora striata. In a vertical section by the optic commissure (Fig. 436), will be seen the *caudate nucleus* limiting outwardly the lateral ventricle, and separated from the lenticular nucleus by a layer of white substance—the *internal capsule;* between the lenticular nucleus and the cerebral cortex there is a certain amount of white matter. If the section is made a little more behind, there will be observed, between the grey matter and the lenticular nucleus, a small greyish band named the *claustrum*; this is separated from the lenticular nucleus by the external capsule.

To sum up, it is easy to perceive that the distribution of the central grey masses (*lenticulo-striated bodies*) is subordinate to the internal capsule. Otherwise, this plays a considerable part in the physiology of the hemispheres.

In the middle of each hemisphere, the *white substance* constitutes a considerable nucleus, which, from its form, is named the *centrum ovale* (Vicq-d'Azyr) (Fig. 427, 1 ; 434, 1), and which is united to that of the opposite side by the great cerebral commissure, or corpus callosum, sending a prolongation into each convolution ; thus exhibiting the exact disposition of the lateral white masses of the cerebellum, with which the nuclei of the hemispheres have also another point of resemblance, in that they are attached to the cerebral peduncles, as the first are to the cerebellar. But the latter peculiarity is less evident than the others—which are at once obvious in horizontal and transverse sections of the brain—and can only be clearly demonstrated by the manipulations necessary to unravel the intimate texture of the white substance.

In studying this texture in brains hardened by nitric acid, washed in pure water, and exposed to dry air for a day or two, we perceive that the white cerebral substance is entirely composed of fine fibrous lamellæ, diverging in every

Fig. 438.

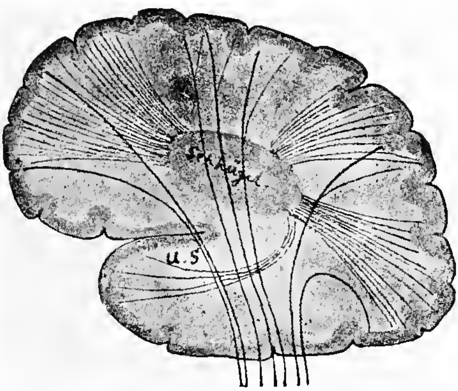


DIAGRAM OF THE COURSE OF THE ASSOCIATION NERVE-FIBRES OF THE CORPUS CALLOSUM AND OF THE ANTERIOR COMMISSURE.

Fig. 439.

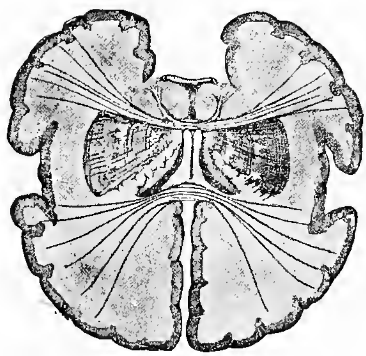


DIAGRAM OF THE COURSE OF THE RADIATING NERVE-FIBRES OF THE CORONA RADIATA, AND THE RELATIONS OF THE CORPORA STRIATA WITH THE CORTICAL GREY SUBSTANCE.

direction, corresponding by their concentric extremity to the centre of the hemisphere, and abutting, by their peripheral extremity, on the inner face of the grey covering of the convolutions.

With regard to the relations between the centrum ovale and the cerebral isthmus, and those the fibres of the former have with the other parts of the brain, it is found that the fibres of the lower stage of the peduncles attach the isthmus to the cerebral hemispheres, in passing through the corpora striata, and radiate in the centrum ovale. Here these fibres form a kind of fan—the *radiant crown* (*corona radiata*) *of Reil*. The internal capsule is the point of departure of these fibres, and is therefore designated the *foot* (*pes*) *of the radiant crown*.

In the *centrum ovale*, the nerve-fibres form two great apparatuses—an *apparatus of association* and an *apparatus of radiation* (Pitres).

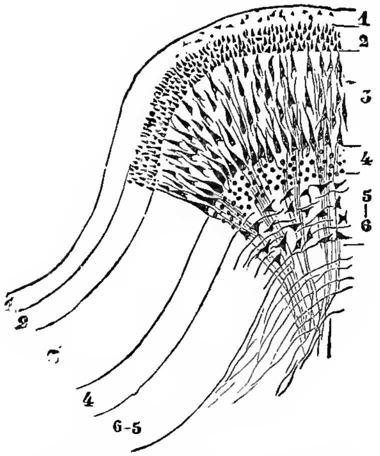
The first comprises a *system of intra-hemisphere commissures*, and a *system of inter-hemisphere commissures*.

The fibres of the first system unite the neighbouring convolutions, and those more or less distant from each other.

The second system comprises the fibres of the corpus callosum. It was formerly believed that these fibres arose from the cerebral peduncles, but now it is thought they pass merely from one hemisphere to another. The anterior commissure belongs also to this system; but great uncertainty exists as to the connections of its fibres.

The radiation apparatus is formed by the fibres of the corona radiata. Among them a great number should proceed, according to Meynert, to the caudate nucleus, the lenticular nucleus, and the optic thalamus (*cortico-striated*, *cortico-lenticular*, and *cortico-optic fibres*). The others form two direct peduncular fasciculi—one, occupying the anterior two-thirds of the corona radiata, going from the motor convolutions of the cortex to the infero-lateral fasciculi of the

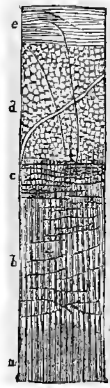
Fig. 440.



ARRANGEMENT OF THE LAYERS AND CELLS OF A FRONTAL CONVOLUTION.

1, Hyaline layer; 2, layer of the *small pyramid cells;* 3, thick layer of the *great pyramid cells;* 4, granular layer; 5, 6, layer of so-called volition cells (beneath this layer is the white fibrillated substance).

Fig. 441.



CORTICAL SUBSTANCE OF THE CEREBRAL HEMISPHERES.

a, Medullary substance; *b*, reddish grey layer; *c*, clear white streak, composed of horizontal fibres; *d*, grey layer; *e*, external white layer.

spinal cord; the other occupies the posterior part of the corona radiata, and passes from the lateral and posterior convolutions of the hemisphere to disappear in the cerebral peduncle. This fasciculus is sensitive.

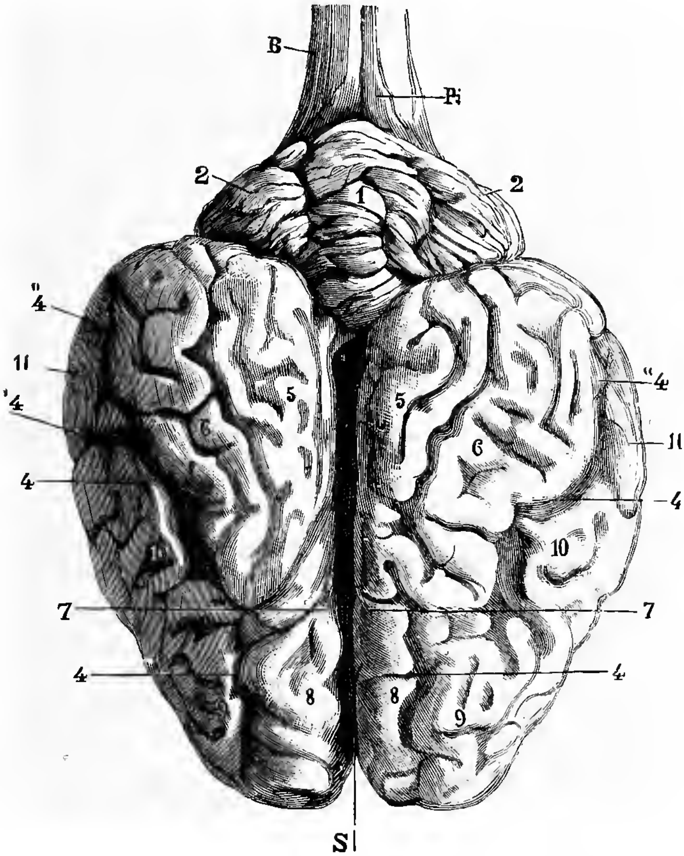
The *white substance* of the brain is formed of very fine nerve-fibres. The *grey substance of the cortex* is made up of five or six superposed layers. In the frontal region there are six layers, as follows: 1. A granular layer, with very small stellate cells. 2. A stratum containing numerous small *pyramidal* cells. 3. A very thick layer with large cells—*great pyramidal*, or giant cells. 4. A granular layer formed of numerous small and uniform cellular elements. 5 and 6. Two layers having for their principal elements stellate or fusiform cells (*volition cells*).

In the occipital region, the third layer is absent; but in the cornu Ammonis it is very developed. Lastly, the *giant pyramid cells* are more particularly found in the cortical regions in the vicinity of the crucial fissure.

The grey substance forming the corpora striata has, for its essential elements, cells analogous to the medium cells of the cerebral cortex.

Vessels.—The *arteries* of the brain come from the three cerebral arteries (see the internal carotid). The branches of these vessels form two systems which have a common origin, but which remain distinct at the periphery. The *cortical*

Fig. 442.



BRAIN OF THE OX (UPPER FACE). THREE-FOURTHS NATURAL SIZE.

B, Neck of the medulla oblongata; Pj, posterior pyramid of the medulla oblongata; S, inter-hemispherical fissure. 1, Middle lobe of the cerebellum; 2, 2, lateral lobes of the cerebellum; 4, 4, anterior part of the fissure of Rolando interrupted by an annectent gyrus uniting convolutions 9 and 6; 4′, inferior part of ditto; 4″, posterior branch of ditto; 5, second parietal convolution with its plaits; 6, first parietal convolution with its plaits; 7, 7, crucial fissure (the sigmoid gyrus surrounding it is hidden beneath the before-mentioned plait); 8, first frontal convolution; 9, union of the second frontal with the limited frontal convolution; 10, limiting front convolution; 11, lobule of the curved plait.

system furnishes blood to the pia mater and the grey cortex. The *central system* leaves the circle of Willis, and is distributed to the ganglionic centres. The arterioles of this system form groups which are generally independent of each other (Duret).

The venous blood from the centre of the hemispheres issues by the vena

Galeni. On the surface of the hemispheres are large veins which enter the sinuses of the dura mater.

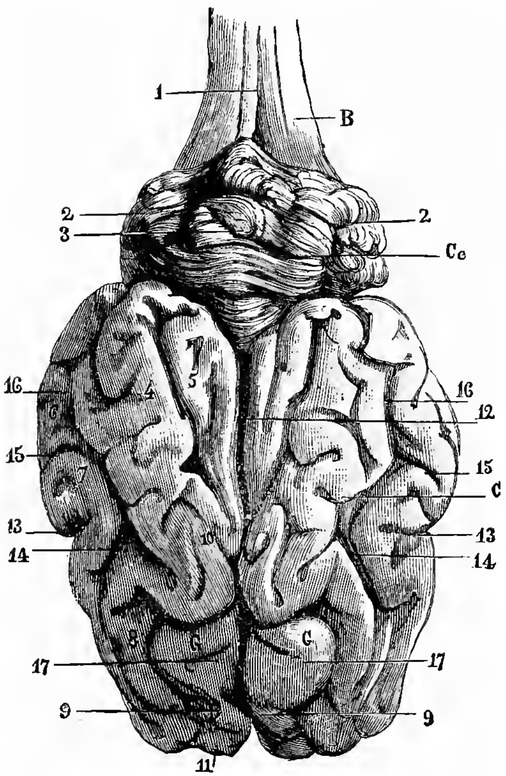
The *lymphatics* form sheaths around the small blood-vessels.

Development.—See "Embryology," for the development of the brain.

DIFFERENTIAL CHARACTERS IN THE BRAIN OF THE OTHER ANIMALS.

In the animals which interest us, the brain presents differences with regard to volume, as might be surmised from what has been stated in our general remarks, when dealing with the cerebrum and cerebellum; in the arrangement of the convolutions there are also important differences.

Fig. 443.



BRAIN OF THE SHEEP (UPPER FACE). NATURAL SIZE.

B, Medulla oblongata: 1, posterior pyramid of ditto. Ce, Cerebellum: 2, 2, lateral lobes of ditto; 3, middle lobe of ditto. C, Right hemisphere of the brain. 12, Inter-hemispherical fissure; 13, 13, upper end of the fissure of Sylvius; 14, 14, fissure of Rolando; 15, 15, postero-inferior branch of ditto; 16, 16, posterior branch of ditto; 4, external parietal convolution; 5, internal parietal convolution; 6, lobule of the curved plait; 7, annectent gyrus uniting the frontal lobe to the lobule of the curved plait, above the fissure of Sylvius; 8, second frontal convolution; 9, first frontal convolution; 10, annectent gyrus uniting the first frontal convolution to the second parietal convolution; 17, 17, crucial fissure. G, G, Sigmoid gyrus.

Ruminants (Figs. 442, 443).—In these creatures, the brain is more globular than in Solipeds. The hemispheres are wider behind than in the Horse and Ass, but they are narrower in the frontal region; there they are a little flattened on each side, and curved downwards.* The *fissure of Sylvius* is deeper at its commencement; its middle branch, much more developed, ascends to near the upper face of the hemisphere; at the bottom of the latter is a V-shaped plait, which unites the ascending frontal convolution to the second frontal convolution. This plait is concealed in Solipeds.

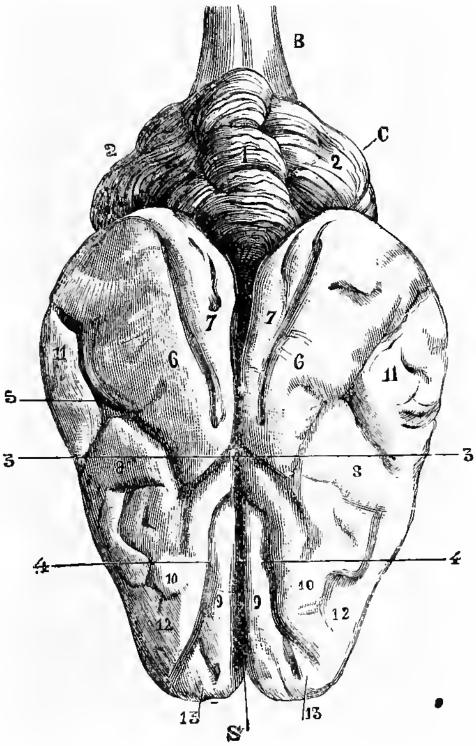
The large fissures are disposed nearly as in the Horse; but it should be noted that the *fissure of Rolando* is interrupted, near its origin, by an annectent gyrus which is thrown from the curved plait on to the ascending frontal convolution, and, in front, by another plait that unites the first parietal convolution to the limited frontal convolution.

The sigmoid gyrus, or its analogue, is concealed between the passage plait that joins the parietal to the frontal convolutions.

In the *Sheep*, the convolutions and the sulci on the surface of the brain are arranged in exactly the same manner as in the Ox, as may be seen in comparing Figs. 442 and 443.

Pig.—The cerebellum is flattened before and behind, against the base of the brain. The latter is much more elongated than in Ruminants. The convolutions are much more simple and less undulating than in the brain of the Ox and Sheep, and in this respect they establish a kind of transition between Ruminants and the Carnivora. In front of the crucial fissure there is a deep incision on the upper border of the hemisphere, and which is continued by a fissure between the two frontal convolutions to the anterior extremity of the brain (Fig. 444).

Fig. 444.



BRAIN OF THE PIG (UPPER FACE). NATURAL SIZE.

B, Medulla oblongata. C, Cerebellum: 1, middle lobe of ditto; 2, 2, lateral lobe of ditto. S, Inter-hemispherical fissure: 3, 3, crucial fissure; 4, 4, deep fissure separating the first frontal convolution, 9, from the second; 12, 13, 5, fissure of Rolando; 6, first parietal convolution; 7, second ditto; 8, limited frontal convolution; 10, annectent gyrus between the limiting frontal convolution and frontal convolutions (probably the sigmoid gyrus); 11, lobule of the curved plait.

The gyri fissures — those which separate the convolutions of each lobe—are larger than in the Horse.

The *convolutions of the frontal lobe* are here also three in number. The ascending frontal and first frontal show scarcely any differences. On the contrary, however, the second frontal passes almost directly backwards, instead of being oblique upwards and forwards, as in Solipeds. Simple in front, it bifurcates behind, and its two branches pass into the ascending frontal convolution.

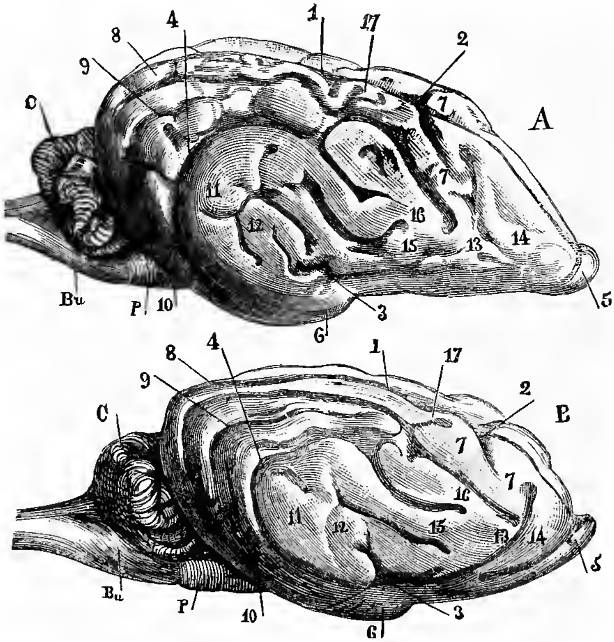
There is nothing worthy of remark with regard to the *temporal lobe*, nor to the lobule of the *curved plait*.

The *first parieto-occipital convolution* is less distinctly divided into two plaits than in the Horse; it joins, in front, the first frontal and the ascending frontal convolution. The second offers nothing in particular.

Dog.—The hemispheres are much more elongated than in the preceding species, except in the Bulldog; the convolutions are very slightly flexuous. At first sight, it is difficult to find on the brain of the Dog the sulci and lobes distinguished in Solipeds; but an attentive examination allows it to be approximated to the brains of these animals.

It is to be noted that the middle branch of the *fissure of Sylvius* (Fig. 445, 3) is very oblique backwards, which causes the *fissure of Rolando* to commence much further back than in Solipeds and Ruminants. This fissure at first ascends backwards, describes a marked curve with concavity antero-inferior, then returns forwards, and terminates by two branches at some distance from the *sigmoid gyrus*, from which it is separated by a plait that unites—as in Ruminants—the first parieto-occipital convolution to the anterior convolutions. The result of this arrangement is that the *frontal lobe* extends well backwards on the external face of the hemisphere. On the other hand, the convolution that occupies the position of the *lobule of the curved plait* is much reduced; it communicates by an annectent gyrus with the *parieto-occipital* lobe. The latter occupies two-thirds of the upper face of the hemisphere; it is limited in front by a very evident *crucial*

Fig. 445.



LATERAL FACE OF THE DOG'S BRAIN. A, MASTIFF; B, BULLDOG.

1, Inter-hemispherical fissure; 2, crucial fissure; 3, fissure of Sylvius; 4, fissure of Rolando; 5, olfactory bulb; 6, temporal lobe; 7, 7, sigmoid gyrus; 8, 9, the two convolutions of the parieto-occipital lobe; 10, convolution of the curved plait; 11, 12, the two plaits of the ascending frontal convolution; 13, 14, frontal convolutions; 15, annectent gyrus uniting the ascending frontal to the frontal convolutions; 16, plait uniting the external parietal to the frontal convolutions; 17, annectent gyrus uniting the internal parietal convolution to the sigmoid gyrus. C, Cerebellum; Bu, medulla oblongata; P, Pons Varolii.

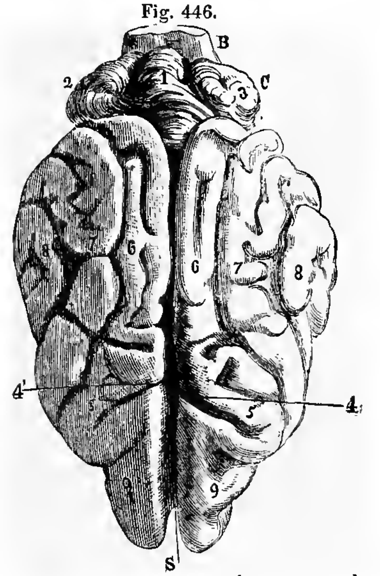
fissure and a *sigmoid gyrus*. The *temporal* lobe is well defined; its parallel sulcus is completely effaced.

To sum up: in the Dog, the lobes and lobules observed in Solipeds and Ruminants are found; their relative extent alone is changed. A word has to be said with regard to the *frontal* and *parieto-occipital* lobes. The first is enveloped by an *ascending frontal convolution* that describes a very sudden flexuosity, and enters the *sigmoid gyrus*. The *second frontal convolution* immediately surrounds the middle branch of the Sylvian fissure; behind, it has the same relations with the ascending convolution as in the Horse; in front, it passes into that convolution. Lastly, the *first frontal convolution* is, like the *orbital lobe* it surmounts, suddenly and greatly flattened on each side; it is nearly smooth, and is joined, behind and downwards, to the *second frontal convolution* and external root of the olfactory lobe; it is confounded, above, with the convolution surrounding the crucial fissure. The upper face of the *parieto-occipital* lobe forms a longer triangle than in Solipeds and Ruminants.

The *first parieto-occipital convolution*, double as in the other animals, bifurcates in front; its internal branch runs into the extremity of the *second convolution* and the *sigmoid gyrus*, while its external branch, as in the Ox, passes on to the ascending frontal convolution. If we supposed this branch interrupted by a notch, the fissure of Rolando would be disposed, in front, in the same way as in Solipeds.

Cat.—The brain of the Cat is more regularly ovoid, and more flattened than

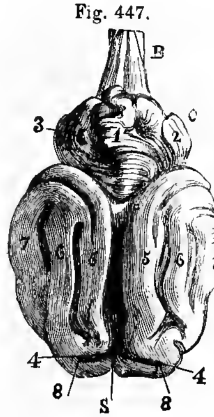
Fig. 446.



BRAIN OF THE DOG (UPPER FACE). NATURAL SIZE.

B, Medulla oblongata. C, Cerebellum: 1, middle lobe of ditto; 2, 3, lateral lobes of ditto. S, Inter-hemispherical fissure; 4, 4', crucial fissure; 5, sigmoid gyrus; 6, second parietal convolution; 7, first parietal convolution; 8, limiting frontal convolution; 9, first and second frontal convolutions.

Fig. 447.



BRAIN OF THE CAT (NATURAL SIZE).

B, Medulla oblongata. C, Cerebellum: 1, middle lobe of ditto; 2, 3, lateral lobes of ditto. S, Inter-hemispherical fissure; 4, 4, crucial fissure; 5, second parietal convolution; 6, first parietal convolution; 7, limiting frontal convolution; 8, sigmoid gyrus.

that of the Dog. The convolutions, less flexuous than in that animal, also affect the longitudinal type, as may be seen in Fig. 447. The crucial fissure is placed quite in front, near the anterior extremity of the hemispheres, which is occupied by a very short, first frontal convolution. The occipital portion of the parieto-occipital lobe is very reduced, and the region it occupies is indented to receive a part of the cerebellum.

Comparison of the Cerebrum of Man with that of Animals.

The cerebrum of *Man* (Fig. 448) is distinguished by its regularly ovoid shape, and its great development, particularly behind, where it covers the cerebellum—a feature never observed in animals.

Viewed superiorly, it shows the upper part of the *frontal*, *parietal*, and *occipital lobes.* The frontal lobe is separated from the parietal by the *fissure of Rolando*, which is very deep, and almost transversely intersects the middle portion of the hemisphere. The parietal lobe is separated from the occipital by the *external perpendicular fissure.*

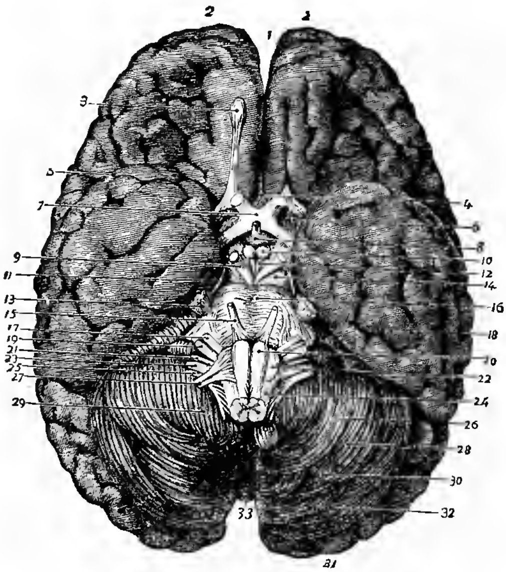
The fissure of Rolando is separated by two large convolutions—the *frontal ascending* and *parietal ascending.*

The inferior face of the hemisphere is intersected by a deep *fissure of Sylvius*, at the bottom of which is found the *lobule of the insula*, when the temporal lobe, situated in front of it, is separated from the frontal lobe, situated behind it.

The internal face presents, besides the parts described in animals, two fissures—the *internal perpendicular* and *vertical branch of the calloso-marginal fissure.* Between these two fissures is the *central* or *quadrilateral lobule*—a dependency of the parietal lobe; in front, the *paracentral lobule* that surrounds the termination of the fissure of Rolando, and the internal face of the frontal lobe; behind, the *cuneiform lobule*, the internal portion of the occipital lobe.

Its *convolutions* are larger, and separated by deeper sulci than in the domestic animals.

Fig. 448.



THE BASE OF THE HUMAN BRAIN.

1, Longitudinal fissure; 2, anterior lobes of cerebrum; 3, olfactory bulb; 4, lamina cinerea; 5, fissure of Sylvius; 6, locus perforatus anticus; 7, optic commissure; 8, tuber cinereum; 9, third nerve; 10, corpus albicantium; 11, fourth nerve; 12, locus perforatus posticus; 13, fifth nerve; 14, crus cerebri; 15, sixth nerve; 16, pons Varolii; 17, portio dura of seventh nerve; 18, middle lobe of cerebrum; 19, portio molliss of seventh nerve; 20, anterior pyramid; 21, glosso-pharyngeal nerve; 22, olivary body; 23, pneumogastric nerve; 24, lateral tract; 25, spinal accessory nerve; 26, digastric lobe; 27, hypoglossal nerve; 28, cerebellum; 29, amygdala; 30, slender lobe; 32, posterior inferior lobe.

The *frontal convolutions* are three in number; the third, or external, indistinct in animals, is situated on the externo-inferior part of the lobule, immediately above the fissure of Sylvius; it is named the *language convolution*, or *convolution of Broca*, to signify that this surgeon demonstrated that it was the seat of language. These convolutions, all proceeding backwards, pass into the ascending frontal convolution.

The *temporal lobe*, which is very developed, shows three undulating convolutions on its surface, distinguished as *first*, *second*, and *third.*

The convolutions of the *lobule of the curved plait* are incomparably more developed than in animals.

Lastly, the *occipital lobe* has three convolutions—*first*, *second*, and *third*—joined to those of the parietal lobe by two annectent gyri.

It may be added that the *olfactory lobes* arise, as in animals, from two orders of roots, but they are small and entirely hidden beneath the inferior face of the frontal lobes.

Examined internally, the brain of Man offers the following principal differences :—

The *corpus callosum* is very developed, and, above the ventricle, forms, from before to behind, a salient angular prolongation named the *frontal cornu* and *occipital prolongation*, or *forceps major*.

There is nothing to note concerning the *fornix* and *septum lucidum*, except that there is a ventricle in the latter which communicates with the middle ventricle by a small aperture—the *vulva*.

The *lateral ventricles* offer remarkable differences. They are not prolonged into the olfactory lobes, but possess a diverticulum that enters the occipital lobe, below the forceps major. This space is more or less developed, and terminates in a point; it is named the *ancyroid* or *digital cavity*, and shows on its floor a small convolution which has been designated the *ergot of Morand* (*pes hippocampi*). The diverticulum and convolution do not exist in animals. The *cornu Ammonis* is slightly uneven on its surface; it is limited, inwardly, by a band, and below this by a grey denticulated lamina—the *gyrus fornicatus*.

The *optic thalamus* forms an enormous prominence on the floor of the lateral ventricle, between the *caudate nucleus* and the *cornu Ammonis*, while it is entirely covered by the latter in the brain of animals.

THIRD SECTION.

THE NERVES.

The *nerves* represent the peripheral portions of the apparatus of innervation. They are cords ramifying in every part of the body, having their origin in the spinal cord or its prolongation—the brain. Before commencing their special study, it is necessary to possess a summary notion of the principal distinctions of which they are susceptible, with regard to their origin, distribution and termination.

Structure.—The nerves are formed by an aggregation of the nerve-tubes already described. These are grouped in primary fasciculi, which are rectilinear or slightly undulating, and enveloped in a sheath of delicate connective tissue—the *perineurium* (*internum*). These primary fasciculi are again collected into bundles to form secondary fasciculi, which are maintained by a layer of fibrillar connective tissue thicker than the perineurium (*perineurium externum*). Finally, these secondary bundles by their union constitute the nerve, around which the connective tissue becomes condensed, and constitutes the *neurilemma*.

(Extremely small septa pass into the secondary bundles of nerves, constituting the *endoneurium ;* from this delicate folds or lamellæ are given off around each nerve-fibre, corresponding to the perimysium of individual muscle-fibres. The coverings of the nerves are anatomically continuous with the connective tissue coverings of the brain and spinal cord. The perineurium consists both of ordinary connective tissue and elastic tissue ; and it is lined by two, and in small nerves by one, layer of endothelial cells, forming the *sheath of Henle*.)

Vessels traverse the connective tissue separating the fasciculi from each other ; they anastomose in a network with elongated meshes which are parallel with the nerve-tubes, and they are also surrounded by the *nervi nervorum*.

(Lymph-spaces exist between the layers or lamellæ of the perineurium, and it would also appear that each individual nerve is surrounded by a lymphatic space, which is continuous with the subdural and subarachnoid lymph-spaces of the spinal cord and brain, while it has no communication with the lymphatics in the vicinity of the nerve. It follows that any increase of pressure in the lymphatic spaces of the central organs, will affect the nerve-ramifications throughout the body.)

On the track of certain nerves is observed a greyish enlargement, or *ganglion.* This is composed of a mass of nerve-cells situated on the course of the tubes. All the upper roots of the spinal nerves are provided with a ganglion. In these spinal ganglia in Mammalia, the nerve-cells are unipolar, and the single prolongation is directed towards the periphery. Ranvier has demonstrated that this prolongation is united to the nerve-tubes of the roots of the nerves at an annular constriction, and that from this arrangement there result T or Y-shaped tubes.

Division.—Nerves are divided, with reference to their destination, into two principal groups: 1. The *cerebro-spinal nerves*, or *nerves of animal life;* 2. The *ganglionic nerves*, or *nerves of organic life.*

Cerebro-spinal nerves.—These emanate directly from the cerebro-spinal axis, and are divided into two secondary groups: 1. The *cranial* or *encephalic nerves*, which arise in the brain, and make their exit by the foramina at the base of the cranium, to be distributed almost exclusively in the head. 2. The *spinal* or *rachidian nerves*, arising in the spinal cord, and passing to the muscular or tegumentary parts of the trunk and limbs, through the intervertebral foramina.

After what has been said with regard to the apparatus of innervation, we know that the fibres composing these cords are distinguished—by their point of origin and their properties—into *fibres of superior origin* or of *centripetal conductibility*, and *fibres of inferior origin* or of *centrifugal conductibility.* The first have a ganglion on their course.

The cerebro-spinal nerves are exclusively formed of the first description of fibres, and are named *sensitive nerves*, as they conduct the stimulus which brings into play the sensibility of the brain. They are distinguished as *nerves of general sensibility* and *nerves* of *special sense.* The first are destined to convey all stimuli except those produced by light, sounds, or odoriferous particles; the second exclusively conduct the latter.

The nerves which are composed only of fibres of the second kind are called *motor nerves*, because it is they which carry to the muscles the spontaneous stimulus to motion originated by the will.

Those which are composed at once of motor fibres and fibres of general sensibility, constitute the *mixed nerves;* these form the largest category.

Ganglionic Nerves.—These nerves—collectively representing the *great sympathetic system*—form below and on the sides of the spine, two long cords, rendered moniliform by the presence of ganglionic enlargements. In the constitution of these cords nearly all the cerebro-spinal nerves concur; their ramifications—frequently ganglionic also—are sent to the viscera of the neck, the thorax, and the abdomen.

In these nerves of organic life are found the two kinds of nerve-tubes—fibres of centripetal and fibres of centrifugal conductibility. But these tubes appear to have only very indirect relations with the brain, for the will has no influence over the organs which receive their nerves from the great sympathetic; and besides this, in health the excitations developed in these organs are all reflected by the spinal cord, and do not provoke in any way the special activity of the brain—they are not felt.

However this may be, it must be remarked that the special anatomical and physiological characteristics of the sympathetic nerves, should not cause them to be considered as a system independent of the first, or cerebro-spinal nerves. The fibres composing both have, in fact, a common origin in the spinal cord—or, rather, those of the ganglionic nerves emanate from the nerve-cords of animal life. In the considerations which follow, we will therefore omit this distinction of the nerves into two groups.

(The nerve-fibres in the sympathetic system of nerves are chiefly non-medullated, and form the preponderance of this kind of nerve-fibre. Sympathetic nerves are whiter than cerebro-spinal nerves, or have a pale-grey hue.)

Origin of the Nerves.—We ought to distinguish in these cords their *real* or *deep origin*, and their *superficial* or *apparent origin*.

The latter is represented by the point of issue of the roots of the nerves, which are ordinarily spread in a fan-shape, then united—generally after a very brief course—into a single trunk, which offers at its commencement a ganglionic enlargement, if fibres of general sensibility enter into its constitution. The inferior spinal roots issue from the bottom of the inferior collateral furrow of the spinal cord; the superior roots from slightly within the superior collateral furrow. Their *real origin* is the point of departure of these roots in the substance of the cerebro-spinal axis. The nuclei of the nerves have been the object of much investigation during recent years, and we therefore know the majority of them. It may be remarked that the cells of the nuclei of the spinal nerves are larger than those of the grey matter of the medulla oblongata. Otherwise, the motor cells diminish in volume from below upwards—that is, from the lumbar region to the medulla oblongata (Pierret).

Distribution of Nerves.—The nerve-trunks, formed by the radicles of which we have just spoken, issue in pairs from the foramina at the base of the cranium or in the walls of the spine, to be distributed to all parts of the body by dividing into successively decreasing branches.

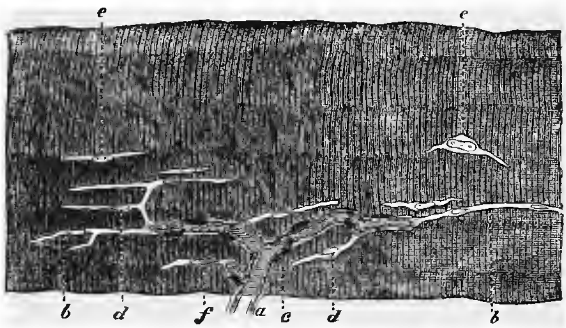
Those among these branches which ramify in the organs of animal life, generally follow the track of the deep vessels or the subcutaneous veins, and are always found most superficial. Their ramescence is effected in a very simple manner, by the successive emission of the fasciculi composing the principal trunks, until these are completely expended. These branches pursue their course nearly always in a direct line; only some—as the ramifications of the two principal nerves of the tongue—describe very marked flexuosities, with the same protective intention as the arteries of that organ. *Anastomoses* sometimes join these branches to one another; and anastomoses—frequently complicated—unite many nerves together, forming what are called *plexuses*. But in these anastomoses, no matter how complicated they may be, there is never any fusion of the nerves, but merely aggregation of their fibres, which always preserve their independence, characters, and special properties. These anastomoses, then, differ essentially from those of arteries, and never permit two trunks to mutually supplement each other when the course of one is interrupted.

The nerves sent to the organs of vegetative life, and which arise from the two subspinal chains in the formation of which nearly every pair of nerves concurs, comport themselves in their distribution in a slightly different manner. They are enlaced around arteries, forming on these vessels very complicated plexiform networks, and yet the fibres composing them are as absolutely independent as in the anastomoses above described.

Termination of the Nerves.—This point should be examined separately in the case of the motor and the sensitive nerves—that is, in the muscles and the integumentary membranes. The distinction, however, is not quite so absolute as this, for the muscles always receive some sensitive tubes with their motor filaments.

In entering the muscles the *motor* nerves divide their branches, still appearing as double-contoured tubes. It was at one time believed that these fibres formed loops (Valentin) in the interior of the muscle, and returned to their starting-point. This opinion has become obsolete since the ultimate termination of the nerves has been studied by Rouget, Krause, Kühne, Kölliker, Engelmann, Ranvier, and others. What is known of this subject is as follows: The voluminous, double-contoured nerve-tubes which, more or less, cross the direction of the muscular fibres, soon divide and form pale tubes, with nuclei disseminated on their course. These tubes contain an axis-cylinder and a medullary layer. They pass on to a muscular fibre in the following manner: the nucleated sheath of the nerve-tube spreads, and is confounded with the sarcolemma; the medulla suddenly stops when it has reached the *motor end-plate*, which is granular and

Fig. 449.



MUSCULAR FIBRES, WITH TERMINATION OF MOTOR NERVE (FROM THE GASTROCNEMIUS OF THE RANA ESCULENTA).

a, Terminal pencil of a dark-bordered nerve-fibre; *b*, intramuscular naked axis-cylinder; *c*, nucleus of the neurilemma; *d*, clavate extremities of the nerve; *e*, spaces of the muscle-nuclei; *f*, terminal knob of nerve, with central fibres and vesicular dilatations of the nerve.

has small nuclei. The axis-cylinder enters this little plate, and breaks up into fibrillæ, which terminate in a manner unknown on coming into contact with the contractile fibrillæ.

(When the ultimate nerve-fibre approaches the muscular fibre, the former loses the white substance of Schwann, while the axis-cylinder pierces the sarcolemma and terminates in the *motor end-plate*. These plates vary much in form and general appearance. Sometimes they seem to consist of very minute fibres, formed by the splitting up of the axis-cylinder, anastomosing so as to form a network, but usually they take the form of irregularly shaped granular masses or discs, containing numerous vesicular nuclei.)

The mode of termination of the *sensitive* nerves varies, according as they are sensorial or general sensibility nerves.

It appears to be demonstrated that the tubes of the sensorial nerves have at their extremity an elongated cell, analogous to that from which they started. An idea has been given of this arrangement in describing the olfactive portion of the pituitary mucous membrane. Other examples will be given when studying the organs of the senses.

The other sensitive nerves—the cutaneous nerves, for example—have been supposed to terminate by peripheral loops, and again by free extremities passing into a kind of cell elements. It is certain that these two modes exist simultaneously; recurrent sensibility, which Claude Bernard demonstrated in some cranial nerves, proves that certain nerves have *pre-terminal peripheral* loops. Our own experiments have shown:[1] 1. That this recurrent sensibility is a general phenomenon belonging to the *sensitive* nerves of the limbs, and even to all the *sensitive* ramifications of the spinal nerves and those of the face. 2. That the recurrent anastomotic loops are formed at different parts along the course of the nerves, either beneath the integuments or in their texture. It may be added that there are found in the papillæ of the skin, in certain regions—hand, foot, lips, tongue, glands, clitoris—the *corpuscles of Meissner*, or tactile corpuscles. These are composed of condensed connective tissue, and are conical, like a pine-cone, the summit towards the periphery. By their base they enter one or more nerve-tubes, which terminate in enlargements. In the conjunctiva, lips, etc., are also found rounded bodies analogous in their structure to the tact corpuscles, and which are named the *corpuscles of Krause*. Lastly, on the course of the collateral nerves of the fingers and in the mesentery of the Cat, are the *Pacinian corpuscles*, or *corpuscles of Vater*—small globular or ovoid bodies, formed of several concentric layers of tissue, and with a central cavity or canal into which penetrates and terminates—by one or more enlargements—a filament from the nerve-trunk (reduced to the axis-cylinder only).

CHAPTER I.

The Cranial or Encephalic Nerves.

THE *cranial nerves* leave the brain in pairs, regularly disposed to the right and left, and designated by the numerical epithets of first, second, etc., counting from before backwards.

Willis, taking for a basis the number of cranial openings through which the nerves passed, divided them into nine pairs, with which he described the first spinal pair, making it the tenth in the series of cranial nerves. This division being faulty in some respects, it was sought to perfect it. Haller commenced by removing the first spinal or suboccipital pair of nerves to their proper region; then followed Sœmmering and Vicq-d'Azyr, who doubled the seventh pair of Willis, and reduced his eighth into three distinct pairs, according to considerations derived from the destination and uses of these nerves. The number of pairs of cranial nerves, their order of succession, and their nomenclature were then established in the following manner:—

[1] Arloing and Tripier, "Recherches sur la Sensibilité des Téguments et des Nerfs de la Main" (*Archives de Physiologie*, 1869).

1st pair, or olfactory nerves	corresponding to the	1st pair of Willis.
2nd pair, or optic nerves		2nd pair „
3rd pair, or common motores oculorum nerves		3rd pair „
4th pair, or pathetici nerves		4th pair „
5th pair, or trigeminal nerves		5th pair „
6th pair, or abducentes nerves		6th pair „
7th pair, or facial nerves		7th pair „
8th pair, or auditory nerves		(7th pair)
9th pair, or glosso-pharyngeal nerves		8th pair „
10th pair, or pneumogastric nerves		(8th pair)
11th pair, or accessory or spinal nerves		(8th pair)
12th pair, or great hypoglossal nerves		9th pair „

In the following table, these nerves are classed according to their properties :—

1. Nerves of special sense	olfactory nerves	or 1st pair.
	optic nerves	2nd „
	auditory nerves	8th „
2. Mixed nerves with double roots	trigeminal nerves	5th „
	glosso-pharyngeal nerves	9th „
	pneumogastric nerves	10th „
3. Motor nerves with single roots	common motores oculorum nerves	3rd „
	pathetici nerves	4th „
	abducentes nerves	6th „
	facial nerves	7th „
	accessory or spinal nerves	11th „
	great hypo-glossal nerves	12th „

(Sir Charles Bell considered the fourth, seventh, and eighth nerves as forming a separate system, and to be allied in the functions of expression and respiration. In consonance with this view, he termed them *respiratory nerves*, and named that portion of the medulla oblongata from which they arise, the *respiratory tract.*)

One of the characteristics of the cranial nerves being their diversity, it is scarcely possible to study them as a whole, and it is only in their *origin* that they resemble each other in some points. A good idea of their origin is given in Fig. 452.

Preparation of the cranial nerves.—Four preparations are necessary for the study of the cranial nerves:

1. A brain extracted after opening the cranium by its base, and hardened by prolonged immersion in alcohol or very diluted nitric acid. This piece permits the origin of the nerves to be studied (Fig. 424).

2. The superficial nerves of the head; these are the auricular nerves, and the divisions of the subzygomatic plexus, with the infra-orbital and mental branches, as well as the superficial ramuscules of the three nerves of the ophthalmic branch of the fifth pair (Fig. 168).

3. A piece disposed as in Fig. 454, for the study of the maxillary nerves. To prepare it, the greater part of the masseter muscle should be removed in dissecting the massteric nerve; the globe of the eye must be extirpated, the orbital and zygomatic processes excised, the two maxillary sinuses opened, and the branch of the inferior maxillary bone chiselled off as in the figure. Lastly, the anastomosis of the facial with the subzygomatic nerve is dissected, by cutting away the parotid gland.

4. The deep nerves, including those of the globe of the eye; this preparation should be made by following exactly the instructions given for dissecting the arteries of the head. Figs. 450 and 454 will serve as guides for details.

The pneumogastric and spinal nerves, which are not included in these considerations, should be prepared and studied at the same time as the great sympathetic. When treating of the latter, we will refer to them.

Preparations 2, 3, and 4 may be made on one head, and simultaneously. With this object, the head is skinned, and the facial panniculus, beneath which the branches of the subzygomatic plexus lie, is removed. The parotid gland is carefully dissected off, to expose the subparotideal branches of the facial nerve; then proceed as if preparing the muscles of the tongue and pharynx and the arteries of the eye. Finally, the branches of the fifth pair, hypoglossal, glosso-pharyngeal, and ocular nerves are exposed by freeing them from the tissues surrounding them.

To follow more easily the ramifications of the cranial nerves in their intra-osseous course, the head may be macerated in a bath of diluted nitric acid. The bones being softened, are more easily cut and chiselled, while at the same time the nerves themselves are rendered more firm and apparent by the dissolution of the connective tissue.

1. First Pair, or Olfactory Nerves (Figs. 423, 424).

The first cranial pair is constituted by the olfactory lobules, the anterior extremities of which give off a great number of nerve-filaments; these pass through the cribriform foramina to ramify in that part of the pituitary membrane lining the bottom of the nasal fossæ.

Each olfactory lobule is connected with the brain by two roots—an external and an internal—both composed of white substance (Fig. 424). The external commences by a grey-coloured convolution which borders, externally, the temporal lobe of the hemisphere. The internal, followed from before backwards, turns round in the interlobular fissure, in front of the optic commissure, to mix with the cerebral convolutions. These two roots circumscribe a triangular space occupied by the extra-ventricular nucleus of the corpus striatum, which they embrace. In brains which have been macerated for a long time in alcohol, it is easy to see that the fibres of these roots are continuous, in very great part, with those of the corpus striatum, and leave with the fasciculi of the isthmus, which radiate and spread through the grey matter of the corpus striatum.

According to Meynert and Luys, a portion of the radicular fibres of the olfactory nerves intercross in the substance of the white commissure of the encephalic isthmus.

After the union of its two roots, the olfactory lobule is constituted by a wide white band that passes forward on the inferior face of the hemisphere, and soon terminates in a very elongated oval dilatation lodged in the ethmoidal fossa. This bulb is formed by grey substance on its inferior face, and white substance on the superior. It is said to be a flattened ganglion laid on a band of white substance, which at first represents in itself the olfactory lobule.

We have already seen that this lobule is hollow, and that it communicates with the lateral ventricles of the brain. This peculiarity, added to the special features of its external physiognomy, might, it appears to us, give rise to doubts as to the real nature of the lobules in question. It is evident that they are not nerves, but rather dependencies of the brain; and it is only conformable to custom that we describe them here as the first pair of cranial nerves.

The real olfactory nerves are the filaments which arise from the inferior face of the ganglion or *olfactory bulb*, and which traverse the cribriform plate to reach the mucous membrane of the nose. Their number corresponds to the ethmoidal foramina. At first very soft, delicate, and easily torn, they are enveloped on their passage through these apertures by a very strong neurilemma, which gives them great solidity. Some, in ramifying, descend on the septum nasi; others—and these are the most numerous—divide on the ethmoidal cells, where they form fine and more or less plexuous tufts among the no less interesting divisions of the ethmoidal branch of the ophthalmic artery. Their terminal extremities do not descend below the upper third of the nasal fossæ, but remain confined to the bottom of these cavities.

These are the special nerves of smell. They receive the impression of odours and transmit it to the brain ; this function, which has been accorded and refused them time after time, appears to be now definitively accepted.

2. Second Pair, or Optic Nerves (Fig. 424).

The nerves of vision present for consideration in their interesting study, their *origin*, *course*, *termination*, and *properties*.

There has been much dispute—and there will probably be much more—with regard to the *origin* of the second pair. But without confining ourselves to an appreciation of the opinions which have pervaded science on this matter, we will describe what we have observed in the domesticated animals.

When the isthmus is isolated from the brain (Fig. 426, 12) and examined laterally, we recognize on its anterior limit the white band that constitutes the optic nerve. Studied at its origin, this band is continuous, in the most evident manner, with the external side of the thalamus opticus, where it forms the two enlargements known as the *corpora geniculata*. This thalamus ought, therefore, to be regarded as the point of departure of the nerve that bears its name. But as the external corpus geniculatum is in contact with the *natis*, and as the internal is united to the *testis* by a band of white fibres, it is almost certain, according to several authorities, that the corpora quadrigemina concur in furnishing the constituent fibres of the optic nerves.[1]

At first wide and thin, the optic band (*tractus opticus*) is rolled round the cerebral peduncle downwards and forwards, and gradually narrows. Arrived at the inferior surface of the brain, it is changed into a funicular cord, which unites with that of the opposite side to form the *commissure* or *chiasma of the optic nerves ;* this is only a temporary fusion, as beyond it the two nerves reappear, each passing into the optic foramen, to reach the interior of the ocular sheath and the bottom of the globe of the eye.

We will enter into some details on the relations of the optic nerves in the different points of the *course* we have indicated.

In their flat portion, or origin, they are comprised between the cerebral peduncles and the hemispheres. From the point where they arrive free, at the inferior face of the brain, to the commissure, they are covered by the pia mater, and adhere by their deep face to the superior extremity of the peduncles.

The *commissure* is lodged in the optic fossa, and receives on its deep face the insertion of the small grey lamina which bounds the third ventricle in front ; for which reason this is generally described as the *grey root* of the optic nerves. But of all the proper connections of the commissure, the most important are certainly those which each nerve maintains with its congener at their junction. What becomes of the fibres of each nerve in this anastomosis ? Do they cross one another to reach the opposite eye ; or do they merely lie together, and afterwards separate, in order to go to the eye on their own side ? Anatomy demonstrates that the fibres of the commissure do not exclusively affect either of these arrange-

[1] To the optic nerve has been attributed two roots, which are two portions of the small band of that name. The external root arises in the optic thalamus, the external corpus geniculatum, and the anterior corpora quadrigemina; the internal leaves the internal corpus geniculatum. According to certain authorities, the two roots pass to the same points; but others assert that they reach the four corpora quadrigemina.

ments; for in studying them in a specimen that has been macerated for some days, it is found that the majority cross each other in a very evident manner, but that a part regain the nerve corresponding to the side from which they came. It is therefore seen that the nerves of the second pair are composed of one kind of fibres on this side of the commissure, while beyond it they show two kinds—the fibres from the right and left sides. The majority, we have said, cross each other; and the proof of this is afforded in certain facts observed in pathological anatomy, which are of sufficient interest to be mentioned here. In the cases so frequently occurring in the Horse, when an eye is lost from the ravages of periodic ophthalmia (*fluxion périodique*), the consecutive atrophy of the optic nerve nearly always stops at the commissure, though it sometimes happens that it gets beyond this; and it is observed that it is usually the nerve opposite to the diseased eye which suffers the most. Otherwise, the arrangement just described is only a degree less advanced than that remarked in certain species—in the osseous fishes, for instance—in which the optic nerves entirely cross each other without confounding or mixing their fibres.

But behind the ganglionic centre of these nerves, contained in the corpora geniculatum and quadrigemina, the direct fibres of the optic nerves cross each other, and reach—along with those that crossed at the commissure—the sensitive centre spread in the grey substance of the posterior lobe of the brain. This is the opinion of Gudden, Nicati, Charcot, Landolt, etc.; they compare the optic nerves to the other cranial nerves.

Beyond their commissure, the nerves of the second pair are in relation with the walls of the optic foramina; then with the posterior rectus muscle (*retractor oculi*), which envelops each nerve as in a sheath. In the orbital cavities they are also related to some other nerves and vessels.

With regard to its *termination*, the optic nerve enters the globe of the eye by piercing the sclerotic and choroid coats, towards the most declivitous part of its posterior surface, and expands in the form of a membrane, which is described in the apparatus of vision as the *retina*. Before traversing the bottom of the eye, this nerve always becomes markedly constricted.

The study of the *structure* of the optic nerve reveals some peculiar facts which it is well to know, though they are more curious than interesting. The upper part is entirely destitute of envelope, while the inferior—that in front of the commissure—has a double neurilemma. The external layer of this is only a dependency of the dura mater—a kind of fibrous sheath attached at one end to the margin of the optic foramen, and at the other to the sclerotica. The internal, which is analogous to the neurilemma of the other nerves, emanates from the pia mater, and shows a multitude of septa (forming the *lamina cribrosa*), which keep the fibres of this nerve apart from each other. To make this organization manifest, the nerve should be steeped in an alkaline solution for some days, and then washed in a stream of water to remove the softened nervous matter; the nerve is to be afterwards tied at one of its extremities, inflated, tied at the opposite end, and dried. By means of some sections, all the canals that lodge the fasciculi of nerve-tubules, and which are formed by the internal neurilemma, are visible.

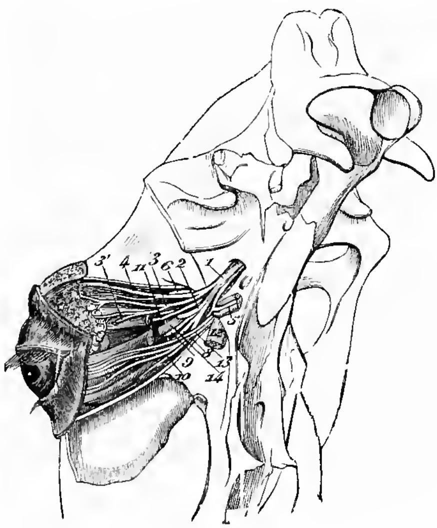
Concerning the *properties* of the optic nerve, we will say nothing; though they are analogous to those of the other nerves of special sense. It transmits to the brain the impressions furnished by the sense of vision, and mechanical irritation of it does not cause pain.

3. Third Pair, or Common Oculo-motor Nerves (Figs. 424, 450).

The nerves of the third pair emanate from the cerebral peduncles, near the interpeduncular fissure, and at an almost equal distance between the corpus albicans and the pons Varolii, in front of the *locus niger*. Their roots, seven or eight in each, penetrate the texture of these peduncles, pass backwards, traverse the red nuclei of Stilling, and may be traced to their nucleus, placed above the anterior border of the pons Varolii. This nucleus is united, in the middle line, to that of the opposite side.

From the union of these roots results a flattened trunk, which is at first carried outward, and is almost immediately inflected forward, to enter—along with the sixth pair and the ophthalmic branch of the trigeminal nerve—the smallest of the great supra-sphenoidal foramina—the *sphenoidal fissure* (*foramen lacerum basis cranii*). The common oculo-motor nerve afterwards arrives, by the orbital hiatus, at the bottom of the ocular sheath, where it separates into several branches destined to the following muscles of the eye: the elevator of the upper eyelid, superior rectus, internal rectus, inferior rectus, posterior rectus—except its internal fasciculus—and the small oblique. The branch to the latter is remarkable for its great length; it reaches its destination in passing to the outside of, and then below, the inferior rectus. The motor roots of the ophthalmic ganglion furnished by this nerve, are given off from the same point as the branch or the small oblique muscle.

Fig. 450.



NERVES OF THE EYE.

1, Ophthalmic branch of the fifth pair; 2, palpebro-nasal branch; 3, lachrymal nerve; 3', temporal branch of that nerve; 4, frontal nerve; 5, external oculo-motor nerve; 6, trochlear nerve; 8, 9, 10, 11, branches of the common oculo-motor nerve; 12, superior maxillary nerve; 13, its orbital branches.

The nerves of the third pair are purely motor, as is shown by their connections with the inferior plane of the cerebral peduncles, and their exclusive distribution to contractile organs. They excite all the muscles lodged in the ocular sheath, except the external rectus, the great oblique, and posterior rectus. They also innervate the constrictive muscular fibres of the iris; the dilating fibres are supplied with nerves by the sympathetic.

4. Fourth Pair, or Pathetici (or Trochlearis) (Fig. 450, 6).

The *pathetic* or *internal oculo-motor* (or *trochlearis*) nerve is the smallest of all the cranial nerves. Its description is extremely simple. It arises from the band of Reil, immediately behind the corpora quadrigemina, by two short roots, which reach the anterior border of the valve of Vieussens, where are some cells, and from there—their real nucleus, which is confounded with that of the common oculo-motor—after intercrossing on the middle line with the pathetic of the opposite side, it is directed outwards, downwards, and forwards, to disengage itself from the deep position it at first occupies, and lies beside the superior branch of the trigeminus, accompanying it to the supra-sphenoidal foramina, the smallest of which it enters (*pathetic canal*). This opening is exclusively intended for it, and carries it to the bottom of the ocular sheath, when it gains the deep face of the great oblique muscle, in which it ramifies.

The physiological study of this nerve gives rise to some very interesting remarks, which we will sum up here in a few words. The two oblique muscles of the eye pivot the ocular globe in the orbit, without causing the slightest deviation either upwards, downwards, or otherwise, of the pupillary opening. But this rotatory movement is altogether involuntary, and is only accomplished in certain determinate conditions. "Guerin, Szokalski, Hueck, and Hélie have remarked, that when the head is alternately inclined to the right or left, while the vision is fixed on any object, the ocular globes describe around their antero-posterior axis an inverse rotatory movement that has the effect of preserving a constant relationship between the object from which the luminous rays proceed and the two retinæ. In this rotatory motion, the great oblique muscle of one side has for its congener the small oblique of the other side : thus, when the head is inclined on the right shoulder, the right eye revolves inwards and downwards on its axis, under the influence of the superior oblique muscle, while the left eye turns on itself outwards and downwards, through the action of the inferior oblique ; when the head is inclined on the left shoulder, an inverse movement takes place in the two eyes. This simultaneous rotation of the eyes around their antero-posterior diameter, when the head is inclined to one side or the other, is necessary for the unity of perception of visual objects ; if one of the two eyes remained fixed while the other turned on its axis, we should perceive two images—a superior corresponding to the healthy eye, and an inferior to the diseased one. These two images are visible when the head is vertical, and particularly when it is inclined to the affected side ; they are merged in one when the head is carried to the healthy side."[1]

The involuntary action of the oblique muscles of the eye in this rotatory movement, strongly attracts attention to the nerves which these muscles receive, and stimulates a desire to learn the particular conditions which permit them to act as excito-motors independently of the will ; although they, as well as the muscles which they supply, belong to those of animal life. In the present state of science, nothing positive can be affirmed on so delicate a subject. There are, nevertheless, two interesting remarks to make : the pathetic nerve is *exclusively* destined to the superior oblique muscle, and the long branch sent by the common oculo-motor nerve to the inferior oblique does not give any filament to the neighbouring parts. This branch is, therefore, also the *exclusive* nerve of the inferior oblique, and may be considered as a second *pathetic*.

(Sir Charles Bell designated the fourth nerve the "respiratory nerve of the eye," and asserted that it was large in all animals capable of much expression.)

5. Fifth Pair, or Trigeminal Nerves (Figs. 451, 452, 453, 454).

The nerve we are about to describe has also been named by Chaussier the *trifacial nerve*. It is distinguished among all the cranial nerves by its enormous volume, the multiplicity of its branches, the variety of its uses, and its connections with the great sympathetic system. It therefore requires to be described as com-

[1] Sappey, *Anatomie Descriptive*.

pletely as possible ; and in this description we will include the study of the cephalic ganglia of the great sympathetic system, which ought to be regarded as annexes of the fifth pair.

Origin.—The trigeminus belongs to the category of mixed nerves, as it possesses two roots—one sensitive, the other motor.

Sensitive root (Fig. 426).—This is the largest root. It emanates from the outside of the pons Varolii, near the middle cerebellar peduncle, and is directed forward and downward to gain the anterior portion of the foramen lacerum, where it terminates in a very large semilunar enlargement—the *Gasserian ganglion.* Flattened above and below, and wider in front than behind, this root on the outer side is about $\frac{3}{5}$ of an inch in length, but the inner side is double that measurement, because of the oblique position of the ganglion which continues it.

If it be traced into the substance of the pons Varolii, it will be found that the fibres of the latter separate for its passage from the deep plane it at first occupies.

Fig. 451.

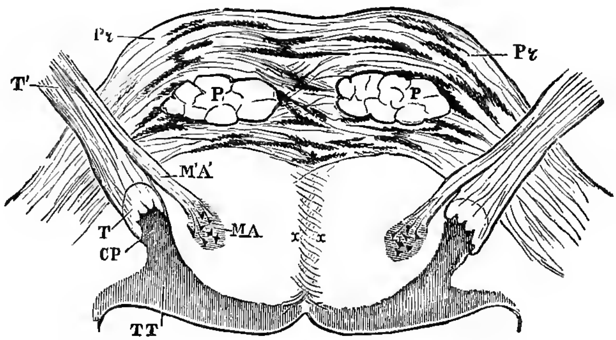


DIAGRAM OF A SECTION OF THE PONS VAROLII OF MAN, AT THE ISSUE OF THE FIFTH PAIR OR TRIGEMINAL NERVE.

PP, Pyramids ; P*r*, transverse fibres of the pons Varolii, with stratification of the grey substance ; TT, grey substance in the floor of the fourth ventricle (*locus cœruleus*) ; CP, gelatinous substance of Rolando ; T, ascending roots of the trigeminus, curving to emerge from the pons—great or sensitive root of the trigeminus ; MA, motor nucleus of the trigeminus ; M'A', small root or motor root of the trigeminus (masticator nerve) ; T', fifth pair at its emergence ; *x*, *x*, raphé.

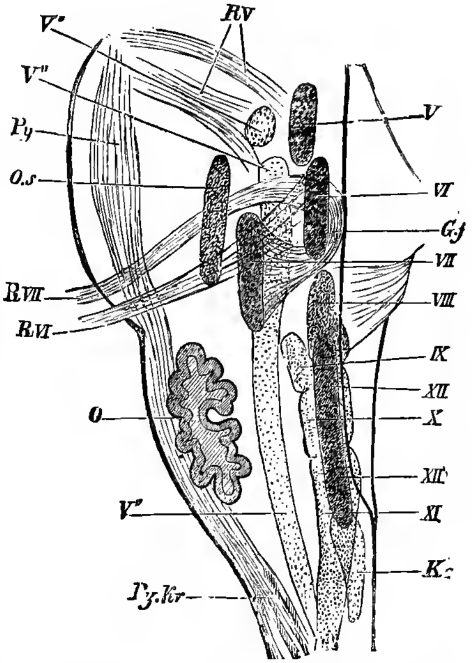
The following is the manner in which it comports itself in this plane : This root is separated into two orders of fibres—posterior and anterior. The first pass beneath the arciform fasciculi of the pons Varolii, to be continued with the grey mass in the medulla oblongata (Fig. 451, CP), which here represents the superior grey cornu of the spinal cord ; the others, anterior, separate from each other, and soon become confounded with the mass of cells in the interior of the isthmus, on the walls of the aqueduct of Sylvius. Others, finally, reach the *locus cœruleus* (TT)—a portion of the grey substance on the floor of the fourth ventricle. The sensitive nucleus of the trigeminus extends from the pons Varolii to the neck of the medulla oblongata ; it is very long (Fig. 452, *V*, *V'*, *V''*). The fibres of the trigeminus—or the cells which receive these fibres—are in communication with several cranial nerves, particularly the pneumogastric, glosso-pharyngeal, facial, and auditory (Fig. 452).

Semilunar or Gasserian ganglion (Fig. 425, 18).—This ganglion, which receives the sensitive root of the trigeminus, is crescent-shaped, its concavity being turned backwards and inwards. It may be said to be embedded in the fibro-cartilaginous substance which in part closes the occipito-spheno-temporal hiatus, and divides it into several particular foramina. Its superior face is covered by the dura mater, and sends a number of filaments to that membrane.

The Gasserian ganglion is not continued by a single trunk, but immediately divides into two thick branches, one of which leaves the cranium by the foramen ovale—an opening formed by the above-named hiatus ; while the other is lodged in the external fissure in the intra-cranial surface of the sphenoid bone, and passing along it as far as the entrance to the supra-sphenoidal foramina, bifurcates.

Hence it results that the trigeminus is divided—even at its origin—into three branches : two superior—the *ophthalmic branch of Willis*, and the *superior maxillary nerve*, commencing by the same trunk ; and an inferior, which constitutes the *inferior maxillary nerve.*

Fig. 452.



LATERAL VIEW OF THE MEDULLA OBLONGATA, SHOWING THE ARRANGEMENT OF THE FIFTH PAIR, AND RELATIVELY OF THE MOST IMPORTANT NUCLEI.

Py, Pyramidal tract ; *Gf*. genu facialis, or bend of the facial nerve ; *Os*, superior olivary body ; *O*, inferior ditto ; *Py.Kr*, decussation of pyramids. The nuclei, situated near the middle line, are darker tinted. The numerals represent the roots of the cranial nerves, according to their number.

Motor or small root (Fig. 426, 8).—This is a flattened band which emerges from the pons Varolii, at the inner side of the principal root. Its fibres may be easily followed to the interior of the pons Varolii (Fig. 451, M'A') ; they disappear in the nucleus of grey substance situated inside the nucleus of the principal sensitive root, near the floor of the fourth ventricle (MA). Leaving the pons Varolii, this root passes forwards on the inferior face of the Gasserian ganglion, which it crosses in a diagonal manner outwards, and beyond which it intimately unites with the fibres of the inferior maxillary nerve. The superior maxillary nerve and the ophthalmic branch do not receive any fibres from it. In the fifth pair, then, it is only the inferior maxillary nerves which are at the same time sensitive and motor, and are real mixed nerves.

A. Ophthalmic Branch (or Nerve of Willis) (Fig. 450, 1).—This is the smallest of the three divisions furnished by the Gasserian ganglion ; it proceeds by a trunk common to it and the maxillary nerve, which will be described hereafter. This branch enters the smallest of the large supra-sphenoidal foramina, along with the common and external oculo-motor nerves, and in the interior of this bony canal it divides into three ramuscules, which reach the bottom of the ocular sheath by the orbital hiatus.

These ramuscules are :

1. The *frontal* or *supra-orbital* (*supra-trochlear*) *nerve.*
2. The *lachrymal nerve.*

3. The *nasal* or *palpebro-nasal nerve.*

1. **Frontal or Supra-orbital Nerve** (Fig. 450, 4).—This is a flat, voluminous branch placed on the inner wall of the ocular sheath, and proceeding nearly parallel with the great oblique muscle of the eye to the supra-orbital foramen, into which it passes along with the artery of the same name. Undivided before its entrance into this orifice, immediately after its exit from it, it separates into several ramuscules, which meet the anterior auricular nerve, and are expended in the skin of the forehead and upper eyelid.

2. **Lachrymal Nerve** (Fig. 450, 3).—This is composed of several filaments, which ascend between the ocular sheath and the elevator muscle of the eyelid and superior rectus, to enter the lachrymal gland. One of these (Fig. 450, 3′) traverses the occular sheath behind the orbital process, and places itself—from before to behind—on the external surface of the zygomatic process, where it divides into a number of ramuscules, some of which mix with those of the anterior auricular nerve to form the plexus of that name, while the others pass directly into the anterior muscles and integuments of the ear.

3. **Nasal or Palpebro-nasal Nerve** (Fig. 450, 2).—This describes a curve, like the ophthalmic artery, and passes with that vessel into the cranium by the orbital foramen. After coursing through the ethmoidal fissure that lodges the artery, it traverses the cribriform plate, and divides into two filaments—an internal and external, which ramify in the pituitary membrane on both sides of the nasal fossa. Before entering the orbital foramen, this nerve gives off a long branch (*infra-trochlear*) that glides over the floor of the orbit, to reach the nasal angle of the eye, where it is distributed to the lachrymal apparatus lodged there, as well as to the lower eyelid ; it also detaches a long filament to the membrana nictitans and the sensitive roots of the ophthalmic ganglion, which will be noticed hereafter.

B. Superior Maxillary Nerve (Figs. 425, 19 ; 453, 15).—This nerve is the real continuation of the superior trunk given off by the Gasserian ganglion, where we will begin to follow it to its termination, examining briefly the ophthalmic branch already described as a collateral division of this trunk.

Remarkable for its volume, and its prismatic and funicular shape, the superior maxillary nerve proceeds from the inner and upper section of the semilunar ganglion, and at first occupies the fissure on the internal face of the sphenoid bone, outside the cavernous sinus, and is covered at this point by the dura mater. After sending the ophthalmic branch into the smallest of the great supra-sphenoidal conduits—the *great sphenoidal fissure*—it enters the most spacious of these openings—the *foramen rotundum*—arrives in the orbital hiatus beneath the ocular sheath, and, with the internal maxillary artery, passes along the space filled with fat which separates that hiatus from the origin of the infra-orbital foramen, which it follows to its external orifice on the face There it terminates in a number of branches named the *infra-orbital ramuscules* (or *pes anserinus*, from their resemblance to the claws of a goose's foot).

In its course, this nerve gives off a large number of collateral divisions, among which may be more particularly distinguished :

1. An *orbital branch.*
2. The *great* or *anterior palatine nerve.*
3. The *staphyline* or *posterior palatine nerve.*
4. The *nasal* or *spheno-palatine nerve.*
5. The *dental nerves.*

In addition to which are described:

6. The *infra-orbital*, or *terminal branches* of the superior maxillary nerve.

1. **Orbital Branch** (Fig. 450, 13).—This ramuscule arises in the interior of the supra-sphenoidal canal, and enters the ocular sheath with the divisions of the ophthalmic branch. It almost immediately breaks up into two or three very slender filaments, which ascend to the temporal angle of the eye, passing between the fibrous lining of the orbit and the outer surface of the motor muscles of the eye, and are distributed to the eyelids and neighbouring integuments.

2. **Great or Anterior Palatine Nerve (or Palato-maxillary)** (Fig. 215, 3).—It arises from the superior maxillary nerve at the orbital hiatus, from a trunk common to it and the nasal and staphyline branches; it passes into the palatine canal with the palato-labial artery, which it follows to the foramen incisivum, where it stops.

During its course in the palatine canal, this nerve throws off two or three small filaments, which escape by particular foramina to the anterior part of the soft palate—*median palatine nerve*. Frequently they arise from a common trunk before the palato-maxillary nerve enters its canal, and pass to their destination by particular openings. For the remainder of its extent on the roof of the palate, this nerve forms, around the arteries it accompanies, a plexiform network similar to that of the ganglionic nerves; the filaments escaping laterally from it are sent to the soft parts of the palate, as well as to the gums.

3. **Staphyline or Posterior Palatine Nerve** (Fig. 215, 8).—The filaments composing this nerve are very easily separated, and frequently anastomose with those of the preceding nerve. They accompany the palatine artery in the canal of that name, bend in front of the pterygoid process to penetrate the soft palate between the glandular layer and the tunica albuginea. They then become inflected backwards, and ramify either in the mucous and glandular tissues of the velum pendulum, or the palato-pharyngeal and circumflexus-palati muscles. This destination, therefore, indicates in this nerve the presence of motor fibres; we shall see hereafter whence they come.

4. **Nasal or Spheno-palatine Nerve.**—Springing from the same trunk as the two preceding nerves, thicker than the staphyline, and nearly of the same volume as the anterior palatine, the nasal nerve passes with its artery into the nasal or spheno-palatine foramen, to penetrate the cavity of the nose, where it separates into two branches—external and internal, which are distributed to the pituitary membrane.

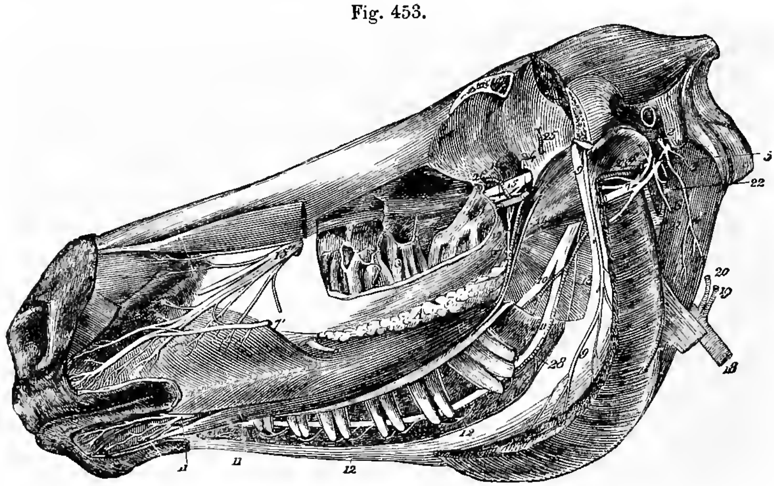
5. **Dental Branches.**—These are destined to the roots of the upper teeth, and proceed from the superior maxillary nerve during its intra-maxillary course; some even arise before the entrance of that nerve into the bony conduit which it passes through to reach the face. These latter—analogous to the *posterior dental nerve* of Man—enter the canal with the parent branch, and throw their divisions into the roots of the last molar tooth, and sometimes also into the second last. One portion of them plunges directly into the maxillary protuberance, to be expended in the mucous membrane lining it, after furnishing some filaments to the periosteum.

Among the dental branches given off from the maxillary nerve during its interosseous course, some pass to the molars, and others to the canine and incisor teeth. The first—or *middle dental nerves*—separate in groups from the maxillary trunk on its passage above the roots of the molar teeth; they penetrate these roots after a brief forward course, and give some thin filaments to the membrane lining the maxillary sinuses.

The second is only at first a single branch—the *anterior dental nerve*—which rises from the maxillary trunk shortly before it leaves its bony canal. After a somewhat long course in the substance of the maxillary bones, this branch becomes expended in ramuscules for the canine tooth and the incisors; it is always accompanied by a very slender arterial twig.

6. **Infra-orbital or Terminal Branches of the Superior Maxillary Nerve.**—These ramuscules spread on the side of the face in a magnificent expansion, which may be looked upon as one of the richest nervous apparatuses

Fig. 453.



GENERAL VIEW OF THE SUPERIOR AND INFERIOR MAXILLARY NERVES.

The eye has been excised, after sawing through and removing the orbital and zygomatic processes. The maxillary sinuses have been exposed by means of a gouge or chisel, the masseter muscle removed, and the inferior maxilla opened to show the nerve in its interosseous course.

1, *Facial nerve;* 2, origin of the posterior auricular nerve; 3, filament distributed to the stylo-hyoid muscle; 4, digastric branch; 5, trunk of the anterior auricular nerve; 6, origin of the cervical filament; 7, plexus formed by the union of the facial and superficial temporal nerve; 7′, branch of that plexus united to the infra-orbital nerves, 15′; 11, *inferior maxillary nerve*; 8, superficial temporal nerve; 9, masseteric nerve; 10, gustatory nerve; 12, 12, dental branches; 13, mylo-hyoidean nerve; 14, buccal nerve; 15, *superior maxillary nerve;* 16, spheno-palatine ganglion; 17, staphyline (or palatine) nerve; 18, *common carotid artery;* 19, trunk of the occipital; 20, trunk of the internal carotid; 21, external carotid; 22, trunk of the posterior auricular artery embraced by a loop of the facial; 23, trunk of the superficial temporal; 24, internal maxillary artery; 25, trunk of the deep anterior temporal artery; 26, orbital branch of the superior dental; 27, buccal artery; 28, inferior dental artery.

in the animal economy. Covered at its emergence from the infra-orbital foramen by the levator labii superioris proprius muscle, this fasciculus descends beneath the levator labii superioris alæque nasi and lateral dilator of the nostril towards the nostrils and upper lip, which receive the terminal extremities of its constituent branches in the substance of their muscular and tegumentary tissues; these branches are slightly divergent and flexuous, and for the most part anastomose with a large motor trunk furnished by the facial nerve (Fig. 453, 15′).

C. Inferior Maxillary Nerve (Figs. 168, 12; 453, 11).—At its exit from the cranium, this branch is situated immediately within the temporo-maxillary articulation, and thence is directed forward and downward, passing at first between the two pterygoid muscles, then between the inner and deep face of the maxilla, arriving at the inferior dental foramen, through which it passes and runs along the whole course of the canal, escaping at last by the mental foramen to form an expansion of terminal branches similar to those of the superior maxillary nerve, and named the *mental nerves.*

For the first third of its extent, the inferior maxillary nerve is a flattened band; but beyond this it becomes thicker, and acquires a funicular shape.

At its origin it gives rise to four branches—

1. The *masseteric nerve.*
2. The *buccal nerve.*
3. The *nerve of the internal pterygoid muscle.*
4. The *superficial temporal or subzygomatic nerve.*

After its emergence from between the two pterygoid muscles, it furnishes—

5. The *gustatory nerve.*
6. The *mylo-hyoidean nerve.*

In its intermaxillary course, it detaches—

7. The *dental branches.*

Also a triple series of collateral nerves, which we will study before describing the terminal branches; these are—

8. The *mental nerves.*

The trunk of the inferior division of the fifth pair represents a mixed nerve, because it is formed of sensitive and motor fibres. Is it the same for each of the branches just enumerated: this is, do they all contain fibres of the two orders? This is a question on which the dissection of the two roots has taught us very little, for their fibres soon become confounded so intimately that it has always been found impossible to follow them separately into each nerve. But the study of the distribution of these branches, corroborated by physiological experiments, has greatly enlightened us in this inquiry. We see among them nerves destined to the muscles, and others to glandular or integumental structures; the first are therefore chiefly composed of motor fibres, like all other muscular nerves; and the second exclusively contain sensitive fibres, or at least are destitute of voluntary motor fibres. In describing each branch in particular, we shall notice their special properties.

1. **Masseteric Nerve** (Fig. 453, 9; 459, 2).—It is detached from the principal trunk, in front of, though close to, the base of the cranium, bends round the anterior face of the temporo-maxillary articulation, and passes through the sigmoid notch of the inferior maxilla to descend into the texture of the masseter muscle and there ramify.

At its origin, this nerve furnishes two filaments which often proceed from one very short trunk, and ascend to and expend themselves in the temporal muscle; this trunk is, then, the *deep posterior temporal nerve.*

Before crossing the corono-condyloid notch, it detaches to this same temporal muscle a small branch which represents the *deep middle temporal nerve.*

The destination of all these branches sufficiently proves that they are motor.

2. **Buccal Nerve** (Figs. 453, 14: 459, 4).—This nerve, which is twice the size of the preceding, arises from the same point, though slightly below it. It is directed forwards, traverses the external pterygoid muscle, and reaches the posterior extremity of the superior and great molar gland; leaving this, it is placed beneath the buccal mucous membrane, and descends to the commissure of

the lips, along the inferior molar gland and the inferior border of the buccinator muscle.

It gives some very fine filaments to the external pterygoid, in its passage across that muscle. Beyond this, it furnishes a very slender ramuscule to the orbital portion of the temporal muscle—the analogue of the *anterior deep temporal nerve* of Man.

On the superior molar gland, it emits a fasciculus of branches to this organ and the buccinator muscle. In its submucous track it throws off, at certain distances, ramuscules of various sizes which go to the inferior molar gland and the buccal membrane; while its terminal filaments are expended in the lining membrane and glands of the lips, near the commissure.

The majority of the filaments given off by this nerve to the external pterygoid and temporal muscles are doubtless motor, but the other ramuscules are sensitive; even those distributed to the buccinator muscle are no exception, for its submasseteric portion is supplied by the facial, as well as the superficial or anterior part.

3. **Internal Pterygoid Nerve.**—It forms, with the preceding nerves, a single fasciculus, which leaves the anterior part of the inferior maxillary nerve. After crossing, outwardly, the internal maxillary artery, it descends between the nervous trunk from which it emanated, and the external layer of the tensor palati muscle, to go to the inner side of, and become expended in, the internal pterygoid muscle.

This nerve is the smallest branch of the inferior maxillary trunk, after the mylo-hyoidean, and excites the contraction of the muscle receiving it.

4. **Superficial Temporal, Temporo-auricularis, or Subzygomatic Nerve** (Figs. 453, 8; 459, 3)—This arises from the inferior maxillary nerve, at the opposite side of the fasciculus formed by the three preceding branches, or posteriorly. Placed at first at the inner side of the temporo-maxillary articulation, and between it and the guttural pouch, it is afterwards directed downwards and outwards, passes between the parotid gland and the posterior border of the inferior maxilla, and below the condyle; it then bends round the neck of that bony eminence to arrive beneath, and to the outside of, the precited articulation, where it terminates by anastomosing with the facial nerve.

In its course it sends off numerous fine filaments to the guttural pouch, the parotid gland, and the integuments of the temporal region. Among the latter, it is necessary to notice more particularly those which accompany the superficial temporal artery.

This nerve appears to be exclusively sensitive. Section of it, before it anastomoses with the facial nerve, does not really prevent contraction of the muscles which receive the divisions of the plexus formed by this anastomosis.

5. **Lingual or Gustatory Nerve** (Figs. 453, 10; 459, 5).—The gustatory nerve—the principal branch of the inferior maxillary trunk, which it almost equals in volume—is detached at an acute angle from the anterior border of that nerve shortly after its exit from the pterygoid muscles. To accomplish its course, which it effects in describing a slight curve with concavity antero-posterior, it is directed forwards and downwards, passing between the internal pterygoid muscle and the branch of the inferior maxillary bone, and gaining the base of the tongue, where it is situated beneath the buccal mucous membrane. It afterwards descends more deeply, between the mylo-hyoid and hyo-glossus longus muscles, turns round the inferior border of the latter—including also

Wharton's duct—to enter the space separating the genio-glossus from the hyo-glossus longus and brevis muscles. From this point it continues to near the free extremity of the tongue, proceeding in a very flexuous manner, and giving off, on its course, divisions equally tortuous, which traverse the organ, but without detaching any ramuscules to the lingual muscles; these divisions terminate in the middle and anterior portions of the lingual mucous membrane.

Before penetrating the mass of the tongue, this nerve furnishes: 1. At, and in front of, the posterior pillars of that organ, some small ramuscules which are sometimes plexiform, and are distributed to the mucous membrane at the base of the tongue. 2. Lower, and behind, one or two thin filaments which are carried to Wharton's duct, and ascend with it to the maxillary gland. 3. A *sublingual* branch, the divisions of which enter the gland of that name, as well as the mucous membrane covering the sides of the tongue.

The gustatory nerve receives, near its origin, the *tympano-lingual* filament or *chorda tympani*—a branch of the facial nerve soon to be described. Its terminal divisions mix and anastomose with those of the great hypoglossal nerve, in the deep muscular interstice which lodges both.

Physiology teaches us that the gustatory nerve gives to the anterior two-thirds of the lingual mucous membrane ordinary sensation, and, in addition, that special sensibility (or gustatory power) by virtue of which that membrane enjoys the property of appreciating savours. This is its exclusive function. With regard to the tympanic filament from the facial nerve, and which is joined to the gustatory, Bernard is of opinion that it participates in the exercise of this sense of taste. Its radiating fibres extend to the submucous muscular layer of which we have spoken, and on which the lingual papillæ rest, and endow it with the property of acting on these papillæ by adapting them, we may say, to the sapid substances brought into contact with them. Lussana goes further than this, and, basing his statement on observations made on Man and on experiments, asserts that the nerve of the tympanum passes to the mucous membrane, and endows it with the sense of taste. It may be added that Vulpian did not at one time agree to either of these opinions, because, according to his experience, this nerve did not go to the tongue, but stopped at the submaxillary ganglion; now, however, he admits that some of its fibres pass into the lingualis muscle, and may aid in causing movement of the tongue. Prevost, of Geneva, believes that the chorda tympani joins the internal branch of the lingual nerve.

6. **Mylo-hyoidean Nerve** (Fig. 453, 13).—The designation of this nerve indicates its destination and uses. It goes to the muscle bearing its name, and excites its contractility; it arises opposite to the preceding, and, like it, descends between the internal pterygoid muscle and the inferior maxillary bone, adhering somewhat closely to the latter. But arriving at the posterior border of the mylo-hyoideus muscle, it passes to the outside of it, and, meeting the sublingual artery, ramifies with it on the external face of that muscle.

7. **Dental Branches** (Fig. 453, 12).—These are of two orders: some passing to the molar, the others to the canine and incisor teeth. Their description does not merit any special indication.

8. **Mental Nerves, or Terminal Branches of the Inferior Maxillary Nerve.**—Perfectly analogous to the infra-orbital ramuscules, these nerves form a fasciculus by diverging and flexuous branches, which leave the mental foramen to be distributed to the textures of the lower lip, after receiving a branch from the facial nerve (Fig. 453, 11′).

D. The Sympathetic Ganglia annexed to the Fifth Pair.—These ganglia, joined by filaments of communication to the anterior extremity of the great sympathetic nerve, in reality belong to the special system formed by that nerve-chain, as they possess the structure and properties of the other ganglia composing it. It is therefore necessary that we should have a motive sufficiently powerful to induce us to move them from their natural category, and mix up their description with a nerve so different to them in its nature and functions. This motive we find in the intimate relations of contiguity and continuity which these ganglia manifest towards the branches of the trigeminus; in the fact that we sometimes find them united to these branches, and deeply mixed up with their fibres; and also because, in certain cases, they seem to disappear entirely, and then their filaments of emission or reception are directly received or emitted by the fifth pair.

The study we are about to undertake of each of the ganglia, will fully justify what we have advanced. We will precede it by a few words of introduction, as to the general facts relating to these small organs.

The number of sympathetic ganglia annexed to the fifth pair is susceptible of variation, not only in different species, but also with individuals of the same species.

In the domesticated Mammifers, we somewhat constantly—though not invariably—find three principal ganglia placed on the course of the branches emanating from the Gasserian ganglion. These are: 1. The *ophthalmic ganglion*, belonging to the nerve of the same name. 2. The *spheno-palatine ganglion*, annexed to the superior maxillary branch. 3. The *otic ganglion*, which lies beside the inferior maxillary nerve. Anatomists describe other two—the *submaxillary ganglion* and the *naso-palatine* (or *Cloquet's*) *ganglion*; but we have not yet dissected them in Solipeds, though they should exist. The submaxillary ganglion has been found in the Dog at a short distance from the point where the lingual nerve gives off a branch to the maxillary gland. It receives sensitive roots from the lingual, and motor roots (vaso-motor or excito-glandular) from the chorda tympani.

These small bodies possess those common characters which have been so clearly indicated by Longet, and to which we will briefly refer. All are in communication with the superior cervical ganglion by one or more generally very slender filaments, and all receive one or more ramuscules from a sensitive and a motor nerve; these ramuscules—the *afferent branches* of the ganglia—are considered as their *roots*. All, finally, emit from their periphery a more or less considerable number of *emergent branches* or *ramifications*, which share the properties, more or less modified, of the two orders of roots. The description of each ganglion therefore includes, independently of its form, situation, etc., an indication of all these ramuscules—*ramuscules of communication* with the superior cervical ganglion; *afferent ramuscules* or *roots*; and *emergent ramuscules*. This rule can be applied to all the ganglia, and renders their study perfectly methodical.

1. **Ophthalmic (Ciliary or Lenticular) Ganglion.**—This ganglion is readily discovered, as it is always in contact with the common oculo-motor nerve, and united to it near the point where the branch passing to the inferior oblique muscle arises. It rarely exceeds the volume of a grain of millet, and is sometimes so minute that it would altogether escape observation, did we not know exactly where to look for it.

Its *motor root* is generally formed of two very short ramuscules coming from the third pair. Its *sensitive root*, much longer, proceeds from the palpebro-nasal nerve; it is usually through the medium of this root that the ophthalmic ganglion communicates with the superior cervical ganglion, by means of a thin filament it receives from the cavernous plexus.

The *emergent filaments* leave the anterior part of the ganglion, and arrange themselves in a flexuous manner around the optic nerve to reach the sclerotica, bearing the name of *ciliary nerves*. Some emanate directly from the palpebro-nasal nerve, especially when the ganglion is rudimentary. Their number is uncertain, though it is usually from five to eight.

Reaching the sclerotica at the bottom of the eye, they traverse that membrane, and pass between its inner surface and choroid coat to the ciliary circle (or ligament), where each divides into two or three ramuscules that anastomose with those of the adjacent ciliary nerves, and in this manner they form a circular plexus. From the concavity of this nerve-circle arises a series of plexuous divisions, which are spread over the iris, influencing its contractile property.

2. **Spheno-palatine, or Meckel's Ganglion.**—The largest of the cranial ganglia, nothing is more variable than its arrangement. The following appears to be the most constant: in raising the superior maxillary nerve in its course across the space separating the orbital from the maxillary hiatus, we discover, lying on the upper border of the spheno-palatine nerve, a long, grey-coloured enlargement; this is the ganglion we are about to describe.

It is elongated and slender, irregularly fusiform, constricted at different points of its extent and dilated in others; it is not attached to the spheno-palatine nerve by simple cellular adhesions or by some branches thrown from one cord to the other, but is intimately united to it by means of a most complicated intercrossing of fibres, in such a way that the spheno-palatine ganglion really forms part of the nerve of that name.

Afferent branches.—It receives, posteriorly, the *Vidian nerve*—a composite ramuscule which constitutes its *motor root*, and connects it with the superior cervical ganglion. This nerve will be described with the facial, as that trunk furnishes its principal portion. Its *sensitive roots* naturally come from the spheno-palatine nerve; they are as remarkable for their number as their volume, and also enter the posterior part of the ganglion.

Emergent branches.—Four series of these are recognized:

(1) A very numerous series which is detached at a right angle from the superior border of the ganglion, and proceeds towards the ocular sheath. The majority appear to be lost in that fibrous membrane, but we have seen some pass through it, creep on the lower and inner wall of the orbit, and arrive at the margin of the orbital foramen. There they were manifestly united to the other filaments coming from the palpebro-nasal nerve, and formed a small plexus, the divisions of which seemed destined to the ophthalmic vessels, and even to some of the muscles of the eye—more especially the oblique ones. Among these divisions, we have observed some which went to join the nerve of the membrana nictitans.

(2) A second series proceeding from the opposite border, and establishing a union between the ganglion and the spheno-palatine nerve, or passing to the palatine nerves in a more or less complicated plexiform manner, to increase them.

(3) A group arising from the anterior extremity and immediately passing to the spheno-palatine nerve.

(4) A last fasciculus detached from the posterior extremity, to enter the two great supra-sphenoidal canals.

Such is the usual arrangement of the spheno-palatine ganglion. We have found it divided into three small masses, connected with each other by numerous filaments of a deep grey colour, and free from all connection with the spheno-palatine nerve. The small posterior mass in this case received the Vidian nerve and the sensitive roots from the fifth pair. The distribution of the emergent branches was unaltered.

Among the anatomo-physiological facts pertaining to the study of this ganglion, we may remark that the staphyline, or posterior palatine, nerve derives from it the motor property which permits it to cause contraction of the muscles in the soft palate.

3. **Otic or Arnold's Ganglion.**—It appears to us that the presence of this ganglion is not constant; for we have sometimes found it replaced by a small plexus, provided with some almost microscopic ganglionic granules.

When it does exist, it presents itself as a small fusiform enlargement placed within the origin of the inferior maxillary nerve, beneath the insertion of the Eustachian tube. To discover it, we have only to look for the commencement of the buccal nerve, to which it is joined by some filaments that are so short and thick, that we might imagine it to be fused on that trunk.

Its *sensitive roots* are represented by the preceding filaments. The small superficial petrosal nerve, coming from the facial, constitutes its *motor root.* From the sympathetic ramuscule accompanying the internal maxillary artery, it receives its *filament of communication* with the superior cervical ganglion.

Among its *efferent ramuscules* must be cited a superior filament, which enters the petrous portion of the temporal bone to disappear in the internal muscle of the malleus (tensor tympani); and two inferior filaments of a more considerable volume, which separate in numerous ramuscules for the pterygoid muscles, the Eustachian tube, and the tensor and levator palati muscles.

Physiological Résumé of the Fifth Pair.—The trigeminus conveys sensation to the skin covering the head, to the eyelids, the soft and hard palate, the nasal fossæ and sinuses, the nostrils, the greater portion of the tongue, the salivary glands and cheeks, and the upper and lower lips. The enormous tuft formed by the terminal branches of the superior maxillary nerve, endow the upper lip with the attributes of an organ of very exquisite tact.

The gustatory branch is, for the anterior two-thirds of the tongue, the essential instrument of the sense of taste.

By its motor root, the inferior maxillary nerve produces contraction of the muscles that bring the jaws into apposition—all those composing the masseteric region, except the digastricus. This root is often designated, in consequence of this function, the *masticatory nerve.*

The fifth pair also influences—as is demonstrated by vivisections and the observation of pathological facts—the secretion of the mucous membranes and glands receiving its filaments. Moussu believes he has experimentally proved that the excito-secretory fibres of the inferior molar and the parotid gland—in the Horse and Ruminants—proceed from the fifth pair, and not from the facial nerve.[1]

Finally, it is admitted that the nutrition of the tissues in which the trigeminus ramifies depends upon this nerve.

[1] He says, with regard to the Horse: "The excito-secretory nerve of the parotid can be isolated from the Gasserian ganglion. It is composed of from four to five filaments, which lie beside either the subzygomatic or the inferior maxillary nerve for a very short distance; then it is placed on the surface of the guttural pouch, and reaches the posterior border of the inferior maxilla and internal maxillary vein, to enter the parotid gland."

The ramuscules sent by the sympathetic chain to the Gasserian ganglion, are perhaps not foreign to the part the fifth pair seems to play in the secretory acts—nutritive and vaso-motor.

Jolyet has found in the superior maxillary nerve, vaso-dilator filaments for the mucous membrane of the nasal fossæ, the skin on the wings of the nostrils and lips, and the mucous membrane of the latter and the gums.

6. Sixth Pair (Abducentes), or External Oculo-motor Nerves (Fig. 450, 5).

The *external oculo-motor* arises from the medulla oblongata, immediately behind the pons Varolii, by from five to eight converging roots, which appear to issue from between the inferior pyramid and the lateral fasciculus of the medulla oblongata (Fig. 424, 9). Its nucleus is confounded with the anterior or superior nucleus of the facial, which will be described presently (Fig. 454, ME).

It is directed immediately forward, leaves the pons Varolii in lying close to the inner side of the superior maxillary nerve, and traverses the foramen lacerum orbitale —which already lodges the ophthalmic branch of the fifth pair and the common oculo-motor nerve—to pierce the bottom of the orbit. It is entirely expended in the external rectus (or abductor) muscle of the eye, after giving off a small ramuscule to the external portion of the retractor muscle.

Fig. 454.

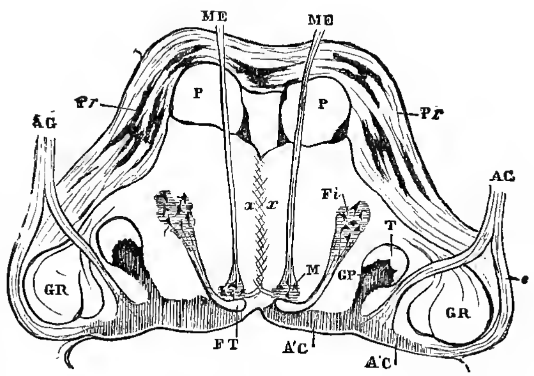


DIAGRAM OF A SECTION OF THE MEDULLA OBLONGATA AND PONS VAROLII OF MAN, AT THEIR JUNCTION.

PP, Pyramids; Pr, Pr, transverse fibres of the pons Varolii (between the various layers of these fibres are irregular strata of masses of grey substance); ME, ME, roots of the external motores oculorum; M, nucleus common to the external motores oculorum and facial nerve; FT, *fasciculus teres* (vertical portion of the genu facialis); Fi, inferior nucleus of the facial, in which arise the radicles that form the fasciculus teres; GP, gelatinous substance of Rolando (head of the posterior cornu); T, ascending or sensitive root of the trigeminus; A'C, grey substance on the floor of the fourth ventricle (nucleus of the auditory nerve); AG, auditory nerve; *e*, external root of ditto; *i*, internal root of ditto; *xx*, raphé; GR, restiform body.

7. Seventh Pair (Portio Dura), or Facial Nerves (Figs. 453, 454).

The *facial* is a nerve exclusively motor at its origin,[1] but it becomes mixed, during its course, by the addition of several sensitive branches.

Origin.—It emanates from the medulla oblongata, immediately behind the pons Varolii, and appears to originate at the external extremity of the transverse band that margins the posterior border of that protuberance. But if we attempt to trace its origin in the substance of the medulla oblongata, we see the single fasciculus it constitutes, at its point of emergence, descend into the groove between the pons Varolii and the above-mentioned band; it then traverses nearly the whole thickness of the medulla, passing between the lateral cord or

[1] See hereafter the description of the great petrosal nerve, for an account of the constitution of the facial nerve.

column, and that portion of the restiform body which is continuous with the large root of the fifth pair. Arrived near the floor of the fourth ventricle, the facial nerve separates into two fasciculi. The less important goes to a nucleus confounded with that of the external motores oculorum ; the other passes backwards, and forms a prominence (*fasciculus teres*) on the floor of the fourth ventricle ; then it is suddenly inflected outwards and forwards, forming a bend (the *geniculate ganglion*, *genu facialis* (Fig. 452, TT) described by Deiters, Vulpian, etc., and terminates in a nucleus (*posterior* or *inferior nucleus*) situated in the lateral parts of the medulla oblongata, on the prolongation of the inferior cornua of the spinal cord (Fig. 452, Fi). The cells of the nucleus are multipolar, pigmented, and larger than those of the anterior nucleus. In the Cat, the principal fasciculus has no bend or *genu*.

Course.—Scarcely has the facial nerve left the medulla oblongata, than it is directed outwards, to pass into the internal auditory meatus, along with the auditory nerve, which lies in contact with it behind. It afterwards enters the aqueduct of Fallopius, courses along it, and follows its inflections, which results in its forming a bend forward at a short distance from the internal opening of the canal, and a curve with concavity anterior, on its passage behind the cavity of the tympanum. On leaving the aqueductus Fallopii by the stylo-mastoid foramen, it is hidden beneath the deep face of the parotid gland, and continues to be inflected forward—passing between that gland and the guttural pouch—and reaches the posterior border of the inferior maxilla, where it issues from beneath the anterior margin of the parotid to become superficial and place itself on the masseter muscle, immediately beneath the temporo-maxillary articulation. There it terminates in two or three branches, which anastomose with those of the superficial temporal nerve from the fifth pair, thus forming the *facial* or *subzygomatic plexus* (*pes anserinus*) (Fig. 168).

Distribution.—*a.* In its interosseous course, the facial nerve successively furnishes—

1. The *great superficial petrosal nerve* (*nervus petrosus superficialis major*).
2. The *small superficial petrosal nerve* (*nervus petrosus superficialis minor*).
3. The *filament of the stapedius muscle* (*tympanic branch*).
4. The *chorda tympani.*

It communicates, besides, with the pneumogastric nerve, by means of a voluminous filament described as—

5. The *anastomotic branch of the pneumogastric.*

b. The branches it emits on its course beneath the parotid gland arise either from its superior or inferior border ; they are—

6. The *occipito-styloid nerve.*
7. The *stylo-hyoid nerve.*
8. The *digastric nerve.*
9. The *cervical ramuscule.*
10. *Filaments to the guttural pouch and parotid gland.*

The superior branches comprise :—

11. The *posterior auricular nerve.*
12. The *middle auricular nerve.*
13. The *anterior auricular nerve.*[1]

[1] It is necessary to add to these branches, those which go to the parotid gland, the stimulation of which excites its secretion. Moussu believes at present, that these excito-secretory branches do not really come from the seventh, but from the ninth pair.

c. To this collection of collateral ramuscules are added the terminal branches, formed by their anastomoses with the superficial temporal nerve—

14. The *subzygomatic plexus.*

A. Collateral Branches.—1. **Great Superficial Petrosal Nerve.**— This is a very remarkable ramuscule, which is detached from the bend of the facial nerve to proceed to Meckel's ganglion. The importance of the peculiarities attaching to the study of this nerve requires us to call special attention to its origin, course, and termination ; though the details into which we are about to enter may be omitted by the student.

Origin.—Ganglion geniculare.—The manner in which the great superficial petrosal nerve comports itself at its origin is yet an obscure and disputed subject, on which, however, light is beginning to be thrown. The following is the most general opinion : This nerve arises from a small grey enlargement, the *geniculate ganglion* (or *intumescentia gangliformis*), placed on the course of the facial nerve, at the summit of the angle which that trunk describes after its entrance into the aqueduct of Fallopius. The presence of this small ganglion on the seventh pair should assimilate the facial to a mixed nerve, the sensitive root of which would be represented by the *portio intermedia of Wrisberg*—a thin filament comprised between the seventh and eighth pairs, and which emanates directly from the medulla oblongata to pass into the posterior part of the ganglion geniculare.

We have constantly found this ganglion in the domesticated animals. There exists, in fact, on this angle or elbow of the facial nerve, a very slight, grey, conical prominence, composed of ganglionic cells which a microscopical examination readily reveals, and giving origin on its apex to the great superficial petrous nerve. This prominence, which, we repeat, is very small, forms part of the facial nerve, on which it only presents a kind of swelling. We have never seen the sharp and precise limitation of its base that is figured in the majority of iconographies of human anatomy.

On the other hand, when, on portions steeped for several weeks in water acidulated by nitric acid, we have studied the constitution of the great petrosal nerve, even at its origin, we have found it formed of two fasciculi very easily separated—one internal, the other external. The latter alone is continuous with the geniculated ganglion ; the other traverses the facial nerve from before to behind, then it is suddenly inflected inwards to ascend to the origin of the nerve, and mix with its fibres. But this fasciculus very often maintains its independence as far as the medulla oblongata, into which its fibres penetrate separately ; they then appear as a small particular trunk beside that of the principal nerve, and comprised between it and the auditory nerve. The great petrosal nerve does not, therefore, proceed exclusively from the ganglion geniculare, as considerable portions of its fibres—entirely destitute of ganglionic cells—emerge directly from the facial nerve. With regard to the external fasciculus, the separation of its fibres by the action of the acid shows very plainly that the grey substance of the ganglion is found almost exclusively on their track ; and if we trace these fibres—like those of the preceding fasciculus—into the substance of the facial nerve, we shall find that, instead of proceeding towards its origin, they appear to be directed to its termination—a remarkable circumstance, which we believe may be explained by admitting that they come from the anastomosing branch of the pneumogastric nerve, of which we will speak hereafter.

From this arrangement, it results that the great petrosal nerve arises from the facial by two real, though intimately connected, roots : the internal is evidently motor; the external possesses the ganglionic cells of a sensitive root; and the trunk they both form may be regarded as a mixed nerve.

As will be observed, our view of the ganglion geniculare differs from the general opinion held with regard to it, inasmuch as we make it belong exclusively to the great petrosal nerve, and not to the whole of the facial fasciculi. On the other hand, the *portio intermedia of Wrisberg* is not, in our opinion, the sensitive root of the facial, the fibres of which we only look upon as motor; it is not even that of the great superficial petrosal nerve, of which it might, at the most, be considered as only an accessory filament. In the Horse, this ramuscule is extremely attenuated, and can scarcely, if at all, be distinguished at its origin from the filaments of the lateral root of the auditory nerve; it is seen to enter the aqueduct of Fallopius, and divide on the bend (or gangliform enlargement) of the facial nerve into several gradually diminishing filaments, which are confounded with the proper fibres of this nerve, or the ganglion geniculare. What a difference there is between this arrangement, and that of the real sensitive roots opposite the ganglia placed on their track!

The opinion which regards the nerve of Wrisberg as the sensitive root of the facial has, we believe, been more particularly accredited by the apparent impossibility of otherwise accounting for the sensibility this nerve possesses, even at its exit from the stylo-mastoid foramen—that is, before contracting any anastomosis with the fifth pair; but this sensibility belongs exclusively to the fibres of the communicating branch sent by the pneumogastric nerve, and not to the fasciculi of the facial, as is proved by stimulating the latter outside the aqueduct of Fallopius, after destroying the pneumogastric at its origin. If it is sought to regard the intermediate nerve absolutely as a branch distinct from the original filaments of the auditory, and if it be determined to make it a sensitive nerve, then it must at least be admitted that it does not carry its sensibility beyond the stylo-mastoid foramen, and that all its filaments disappear in the ramuscules furnished by the facial in its interosseous course. Otherwise, it is known that Longet considers this nerve as forming the small superficial petrosal branch and the nervous filament of the stapedius muscle; but he makes it a motor branch, destined to supply the muscles of the middle ear. His idea is very ingenious, and would assuredly be feasible if it were possible to follow the intermediate nerve from its origin to the lateral column of the medulla oblongata; but, unfortunately, this is not the case, as the small ramuscule only appears to be an offshoot of the fibres proper to the auditory nerve.

To sum up, the great superficial petrosal nerve proceeds from the facial by two roots—one motor, the other sensitive—assimilable, to a certain point, to the roots of the spinal nerves. The first is furnished by the filaments of the seventh pair; while the second probably comes from the pneumogastric nerve, and has annexed to it on its course the ganglion geniculare. The nerve of Wrisberg perhaps concurs in the formation of this ganglion, but it is certainly not its principal source. We ought to add, that a study of microscopical sections of the isthmus has caused Mathias Duval to regard this nerve as an erratic portion of the glosso-pharyngeal; and Pierret has assimilated it to the vaso-motor filaments which leave the lateral column of the spinal cord, to form the *rami communicantes* of the great sympathetic, while the nucleus from which the branch proceeds constitutes the anterior extremity of this column. A good deal of obscurity still prevails with regard to the intermediate nerve, and Sapolini has proposed to make it a thirteenth cranial nerve.

Course and Termination.—The great petrosal nerve, after being detached from the facial, and forming with it an obtuse angle opening outwards, enters the aqueduct of Fallopius—a small passage running from behind forward, in the substance of the petrous bone, above the fenestra rotunda and cochlea. Arriving at the interior of the cavernous sinus—which it passes through, immersed in the blood that sinus contains—it receives a branch from the ganglionic plexus there, is lodged in the Vidian fissure, then in the Vidian canal, and in this manner gains the orbital hiatus, where it separates into several branches—most frequently two—which join the posterior part of Meckel's ganglion. It constitutes the motor root and sympathetic filament of that ganglion.

2. **Small Superficial Petrosal Nerve.**—A very thin filament detached from the facial to the outside of the preceding, and likewise traversing the petrous bone from behind to before, to enter the otic ganglion, as its motor root.

3. **Filament of the Stapedius Muscle (Tympanic).**—The facial nerve, in its passage above and in front of the stapedius muscle, closely adheres to it, and gives it one, perhaps several, extremely short filaments.

4. **Chorda Tympani** (Fig. 459, 6).—This filament—also named the *tympano-lingual nerve*—arises at a very obtuse angle from the facial, near the external orifice of the aqueductus Fallopii; but in reality it co.nes from the trigeminus. It penetrates the cavity of the tympanum by a particular opening, courses from its posterior to its anterior wall in describing a curve downwards, and passes among the chain of auditory bones, between the handle of the malleus and long branch of the incus. Escaping from the middle ear by a canal (*fissura Glaseri*) on the limits of the mastoid and petrous portions of the temporal bone, it proceeds forwards and downwards, and finally joins the gustatory nerve after a short course beneath the external pterygoid muscle, outside the guttural pouch.

It is distributed with the lingual in the mucous membrane of the anterior portion of the tongue, and even, according to Vulpian, in the muscles of that organ; as stimulation of the chorda tympana causes movement of the tongue several days after division of the great hypo-glossal nerve. That physiologist attributes to it all the phenomena that Claude Bernard had observed in the submaxillary gland, after stimulation of the ganglion of that name—vaso-dilating and excito-secretory effects. Consequently, the choroda tympanum should throw a certain number of fibres in that ganglion, and from it into the gland.

5. **Anastomosing Branch of the Pneumogastric Nerve.**—(*See the description of the tenth pair.*)

6. **Occipito-Styloid Nerve** (Fig. 453, 3).

7. **Stylo-hyoid Nerve.**

8. **Digastric Nerve** (Fig. 453, 4).—These three spring from a common fasciculus at the stylo-mastoid foramen, and ramify in their respective muscles, after a certain course beneath the parotid gland.

9. **Cervical Branch** (Figs. 453, 6).—This nerve has its origin almost in the middle of the subparotideal portion of the facial, near a particular loop thrown by that nerve around the posterior auricular artery, and often from this loop itself.

It afterwards traverses the parotid gland from within to without, and above to below, to descend at first on its external face—beneath the parotido-auricularis muscle—then into the jugular channel, where it is lodged below the deep face or in the substance of the panniculus muscle, which receives its terminal divisions near the anterior appendix of the sternum.

In its course this nerve communicates with the inferior branches of the second, third, fourth, fifth, and sixth cervical pairs by branches from them; it sends numerous collateral filaments into the texture of the panniculus.

10. **Filaments of the Guttural Pouch and Parotid Gland.**—Remarkable for their number and tenuity, these filaments do not otherwise deserve particular mention.

11. **Posterior Auricular Nerve** (Fig. 453, 2).—It commences at the stylo-mastoid foramen, is directed upwards beneath the parotid gland, accompanying the posterior auricular artery, and is distributed to the posterior muscles of the external ear. It sometimes has at its origin a loop analogous to that embracing the posterior auricular artery.

12. **Middle Auricular Nerve.**—Most frequently this arise from the same point as the preceding nerve—it might be said in common with it—ascends towards the base of the concha in traversing the parotid gland, and pierces the cartilage to supply the interconchal integument, and the muscular fibres which cover its adherent face in some parts.

13. **Anterior Auricular Nerve** (Fig. 453, 5).—This is the largest of the three auricular nerves. After being detached from the facial nerve, opposite the cervical branch, and after ascending across the parotideal tissue, it gains the external face of the zygomatic process, where it meets the superficial divisions of the lachrymal nerve; it continues forward beneath the external parieto-auricular muscle, reaches the base of the orbital process at the supra-orbital foramen, there crossing the terminal branches of the nerve of that name; it then descends vertically within the orbit to below the nasal angle of the eye, where it mixes with the superficial divisions of the palpebro-nasal nerve, and finally terminates on the face of the lachrymalis and levator labii superioris, alæqui nasi muscles.

In its progress, it gives off numerous ramuscules to the anterior muscles of the ear, the levator palpebræ superioris, and the orbicularis of the eyelids.

This nerve is remarkable for the relations it maintains with the terminal ramuscules of the three branches of the ophthalmic nerve, or fifth pair. Although there do not exist any real anastomoses between it and these various branches, it is customary to designate the reticular mass they form in front of the ear and on the side of the face, as the *anterior auricular plexus*.

TERMINAL BRANCHES OF THE FACIAL NERVE, OR SUBZYGOMATIC PLEXUS (Fig. 168, 11, 12).—The facial nerve, as we have seen, terminates in several branches—usually two, on arriving beneath the temporo-maxillary articulation, where they join the superficial temporal nerve. After becoming sensori-motor, they are continued on the external face of the masseter, covered by the panniculus muscle of the head, to which they give some ramuscules, and are united to each other by anastomosing branches of variable disposition. It is always observed, with regard to this arrangement, that the branches of the subzygomatic plexus, on arriving near the anterior border of the masseter, are divided into a series of divergent ramuscules which pass to the surface of the vascular or glandular canals situated in front of the masseter, to enter the tissues of the lips, cheeks, and nostrils.[1]

[1] The following is an extract from a memoir by Arloing and Tripier, "On the Conditions of Persistency of Sensibility in the Peripheral Extremity of Cut Nerves" (*Archives de Physiologie*, 1876), relating the differences observed in the arrangement of the subzygomatic

Among these ramuscules, the superior is remarkable for its great volume; it passes beneath the zygomaticus muscle, lies close to the inferior border of the dilator naris lateralis, beside the superior coronary artery, and afterwards runs below that muscle, where it joins the terminal ramuscules of the superior maxillary nerve, with which it is distributed to the textures of the upper lip and alæ of the nose (Fig. 453, 7′).

A second ramuscule—the inferior, smaller than the preceding—follows the inner aspect of the depressor labii inferioris muscle, to mix by its anterior extremity with the terminal fasciculus of the inferior maxillary nerve, and ramify—with the proper filaments of that fasciculus—in the tissue of the lower lip.

Between these two principal branches is a series of smaller ramifications destined to the buccinator muscle. Among these are some which become inflected on the inner face of the masseter, and reach the deep portion of the buccinator, where they anastomose with the filaments of the buccal nerve. Other ramuscules—situated below the principal inferior branch—are expended in the panniculus on the face; one of them, after bending round the lower border of the inferior maxilla, reaches the submaxillary space.

Functions of the Facial Nerve.—This nerve excites contraction of the muscles of the middle ear, external ear, the cheeks, lips, nostrils, orbicularis of the eyelids, and the cervico-facial panniculus. By its great superficial petrosal filament, it influences the movements of the muscles of the soft palate, and it is admitted—as already noticed when speaking of the gustatory nerve—that its tympano-lingual ramuscule acts on the submucous muscular layer of the tongue. The facial nerve, also, without doubt, exercises its influence on the parotid gland.

It serves as a medium for the passage for vaso-motor and excito-secretory filaments.

It is to be remarked that the facial nerve has no influence over the masseter

plexus of Solipeds. It is useful to know these differences in accounting for the phenomena that accompany accidental or experimental lesions in this plexus.

As a general rule, the facial nerve divides into two branches close to the parotid gland. The auriculo-temporal nerve divides into three unequal branches when it reaches the maxillary condyle; the upper branch—slender, single, or bifurcated—follows the superficial temporal artery and disappears in the skin of this region, or rejoins in part the temporo-facial plexus. The other branches lie close beside the two branches of the facial nerve—the two nerves being confounded with each other as they proceed to their terminations. This type, which we consider very rare, is modified in various ways:—

1. The sensitive and motor filaments, instead of being confounded suddenly at the anterior border of the parotid gland, may proceed side by side. This separation is generally less marked in the superior temporo-facial branch; when it exists in the inferior branch, the motor filament is situated between the masseter and the panniculus, the sensitive filament between the latter and the skin.

2. Separation of the sensitive and motor portions is complete. The inferior facial branch especially may proceed alone to the lips; the sensitive branch for it follows at first the superior branch of the plexus, and only leaves it about the middle of the masseter, to pass on the cheek and rejoin its satellite motor filament in the lower lip only. In this case, the inferior branch has only filaments from the facial.

3. Instead of a prompt separation between the branches of the temporo-auricular and the facial nerve, there is sometimes observed fusion of the four branches, which may be prolonged some distance beyond the parotid gland. We have seen dispositions of this kind, in which the inferior branch (then always mixed) was detached from the fasciculus, at the level of the eye, in forming a very acute angle.

Sometimes marked differences are observed in the two plexuses in the same animal.

muscle; notwithstanding their intimate relations, it does not detach the smallest filament to it.

Its anastomoses with the various branches of the trigeminus and pneumogastric nerves, endow some of its branches with great sensibility.

8. Eighth Pair, or Auditory Nerves (Figs. 424, 455, 456).

This is the nerve of hearing; it has a very simple disposition, which we will sum up in a few words.

Origin.—The auditory nerve (*portio mollis*) proceeds from the medulla oblongata by two roots—an anterior or lateral, and a posterior. The latter (Fig. 425, 20) commences on the floor of the fourth ventricle by some convergent striæ (*lineæ transversæ striæ medullares*), as is admitted in the majority of treatises on human anatomy—though we have never been able to discover these striæ in the domesticated animals; it is afterwards directed outwards, round the posterior cerebellar peduncle, and unites with the anterior root on the side of the medulla oblongata. The latter root (Fig. 456, *g*), consists of a single fasciculus joined with that of the facial, and escapes from between the fibres of the restiform body. The nucleus of the auditory nerve has been discovered by Schrœder Van der Kolk, a little below that of the facial nerve.

Course and Termination.—These two roots immediately unite into a single soft cord, situated behind that of the seventh pair, with which it is directed outwards to reach the internal auditory meatus. There it divides into two branches—an anterior and posterior—the fasciculi of which traverse the foramina at the bottom of the meatus: the former to gain the axis of the cochlea (the *cochlear* branch), and the latter the semicircular canals (*vestibular* branch). The description of these two branches will be deferred until we come to study the sense of hearing.

9. Ninth Pair, or Glosso-Pharyngeal Nerves (Figs. 456, 3; 459, 10).

The glosso-pharyngeal is a mixed nerve, which conveys general sensation, with gustative sensibility, to the posterior third of the tongue, and excites contraction of the pharyngeal muscles.

Origin.—This nerve originates on the side of the medulla oblongata, behind the eighth pair, by eight or ten fine roots, some of which are implanted in the restiform body; while the others—the smallest number—escape, like the filaments of the facial nerve, from the interstice between that body and the lateral column of the medulla oblongata.[1] The roots of this nerve pass into two different nuclei. The sensitive fibres reach a nucleus (Fig. 455, PN) situated near the floor of the fourth ventricle, in the prolongation of the superior cornu of the medullary axis; while the motor fibres enter another nucleus (Fig. 455, S) belonging also to the hypo-glossal, and which lies in the direction of the inferior cornua of the spinal cord. At their exit from the medulla oblongata, these

[1] This disposition—which is readily exposed in the Horse—appears to us sufficient to remove all the doubts existing in the minds of a large number of anatomists, as to the nature of the glosso-pharyngeal nerve. It evidently possesses at its origin, as motor filaments, those arising from the same part as the facial nerve, and as sensitive filaments those from the restiform body. Besides, we may object to the opinion which would also attribute the motor property of the glosso-pharyngeal nerve to the anastomosing branches passing between it and the seventh pair, on the ground that these anastomoses are far from being constant, and that in some species they are always totally absent.

roots soon unite in a single cord, which issues from the cranium by a particular orifice in the posterior part of the foramen lacerum, and at this point it exhibits a grey oval-shaped enlargement—the *ganglion petrosum* or *ganglion of Andersch*, in which it is somewhat difficult to distinguish the motor filaments of the nerve from those which arise between the lateral and superior columns of the medulla (Fig. 456, 2).

Course and Termination.—Scarcely has the glosso-pharyngeal nerve escaped from the cranium, than it descends, in describing a curve with concavity forward, behind the large branch of the os hyoides, included at first between a fold of the guttural pouch, then between the latter and the internal pterygoid muscle. Lying beside the external carotid artery in the latter part of its course, it passes with it along the posterior border of the great cornu of the hyoid bone, and gains the base of the tongue with the lingual artery, by coursing beneath the hyo-glossus brevis muscle. The papillæ on the posterior portion of the lingual mucous membrane receive the terminal ramuscules of this nerve. (See the *Sense of Taste.*)

Fig. 455.

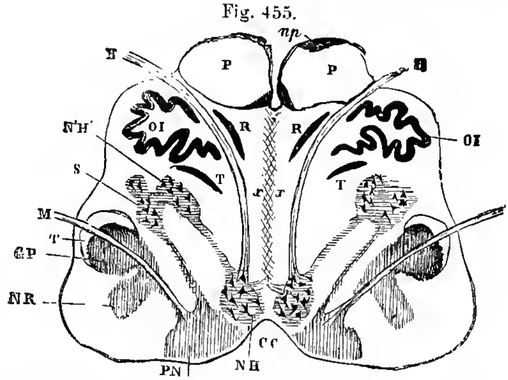


DIAGRAM OF A SECTION OF THE MIDDLE PORTION OF THE MEDULLA OBLONGATA OF MAN.

PP, Pyramids; CC, floor of the fourth ventricle: H, radicular fibres of the great hypoglossal nerve; NH, classical nucleus of ditto; N'H', accessory nucleus of ditto; S, accessory (motor) nucleus of the mixed nerves; PN, sensitive nucleus of the mixed nerves (glosso-pharyngeal, pneumogastric, spinal accessory); NR, nucleus of the restiform bodies; GP, gelatinous substance of Rolando (head of the posterior cornu); T, ascending root of the trigeminus; M, radicular fibres of the pneumogastric; OI, grey layer of the olivary body; R, internal juxta-olivary nucleus; T, external ditto; *xx*, raphé.

Collateral Branches.—On its course it furnishes—

1. *Jacobson's nerve* (*tympanic branch*), a very thin filament springing from Andersch's ganglion, proceeding upwards, and entering a particular foramen in the petrous portion of the temporal bone, to be distributed more especially to the tympanum; sending also to the superficial petrosal nerves two branches, which are designated the *great* and *deep small petrosal nerves.*

2. *Filaments of communication with the superior cervical ganglion*, two or three in number, though sometimes replaced by a single ramuscule.

3. A *branch to the carotid plexus*, which passes back on the guttural pouch to reach the terminal extremity of the common carotid, whence its filaments are sent, with those of the sympathetic nerve, either to the external carotid, occipital, or even to the common carotid artery itself. This branch communicates, by several anastomoses, with the numerous sympathetic branches which pass from the superior cervical ganglion to the surface of the guttural pouch, and which are either expended in that membrane, or join the posterior border of the great hypoglossal nerve.

4. A *pharyngeal branch* (Fig. 459, 11), which is generally detached close to the pharyngeal artery, and forms—along with the pharyngeal filaments of the pneumogastric nerve—a remarkable intricate plexus (*pharyngeal*) on the

upper wall of the pharynx, below the guttural pouch. This plexus receives a filament from the hypoglossal nerve.

10. Tenth Pair, Vagus, or Pneumogastric Nerves (Figs. 452, 455, 458, 480).

The pneumogastric nerve is as remarkable for its extent, as for the multiplicity of physiological uses ascribed to it.

It is prolonged beyond the stomach, after distributing to that viscus, the œsophagus, pharynx, lung, bronchi, trachea, and larynx a large number of filaments on which depend the movements, secretory functions, and purely sensory phenomena of which all these organs are the seat.

Origin.—The pneumogastric is a fixed nerve, and consequently arises from two kinds of roots; these we will successively describe before passing to its distribution, though it must be remarked that this subject has not yet been fully determined.

Sensitive roots.—These arise from a nucleus of grey substance situated near the floor of the fourth ventricle, a little behind the glosso-pharyngeal nucleus—*sensitive nucleus of the mixed nerves* (Fig. 455, PN)—and in which the fibres of the antero-lateral columns of the medulla oblongata, or respiratory tract of Bell, appear to be lost. In leaving the medulla, they form from four to ten bundles, which describe a slight curve with convexity upwards; the highest middle fibres correspond to the groove that limits, superiorly, the respiratory fasciculus, the posterior and anterior fibres bending downwards to the pyramids—the second more than the first.

These roots proceed transversely outwards, mixed with connective tissue and some fine muscular ramifications, and leave the cranium by one of the openings (jugular foramen) in the posterior part of the foramen lacerum, uniting in their passage through that aperture into a somewhat voluminous ganglion, called in Man the *jugular ganglion* (*upper ganglion*, or *ganglion of the root*).

Motor roots.—Several anatomists and physiologists consider these as a portion of the accessory nerve of Willis, and give them the name of *internal* or *bulbar root of the spinal nerve.* They are situated a little behind the preceding, and arise, in the middle of the respiratory tract, from a mass of grey substance which also emits the motor fibres of the glosso-pharyngeal (*motor nucleus of mixed nerves*—Fig. 455, S); consequently, they are not so elevated as the whole of the *sensitive fibres*. They are separated from the latter by a comparatively large vein, and are distinguished from them by their anastomotic tendency. Becoming longer as they are more posterior, and frequently anastomosing with each other, the filaments forming these motor roots converge, and gain the posterior part of the foramen lacerum; this they pass through by one or two special openings to join the jugular ganglion, beneath and behind which we find them applied. A certain number of the most posterior of these filaments lie beside the medullary root of the spinal accessory nerve; but they are soon detached to pass with the others to the jugular ganglion.

Jugular or Ehrenritter's ganglion.—Elongated from before to behind, and flattened above and below, the jugular ganglion is embedded in the cartilaginous substance that fills the foramen lacerum. When it has been macerated for some time in dilute nitric acid, it may be resolved into two portions—one corresponding to the sensitive, the other to the motor roots. Some white nerve-filaments appear to pass to its surface without becoming confounded with it. It is in relation, in front, with the ganglion of Andersch; behind, it crosses somewhat obliquely the medullary root of the spinal accessory nerve.

The jugular ganglion is also in relation with the spinal, glosso-pharyngeal, and facial nerve. It communicates with the *external root of the spinal accessory nerve* by the few radicular filaments indicated above. With the *glosso-pharyngeal* it is connected by: 1. An afferent filament coming from the highest roots of the ninth pair, and which meets it at its antero-internal angle. 2. By an efferent branch it sends to the ganglion of Andersch. 3. Lastly, it is united to the *facial* by a branch we have named the *anastomosing branch, extending from the pneumogastric to the facial nerve.*

This anastomotic branch, on leaving the jugular ganglion, is somewhat considerable in volume, and it has appeared to us that, at times, among its radicles there were some in direct continuity with the sensitive roots of the pneumogastric nerve. This branch is directed forward, above the ganglion of Andersch, crosses Jacobson's branch, traverses the petrous temporal bone, and arrives in the aqueduct of Fallopius; here it meets the facial nerve, at the point where the latter gives off the chorda tympani. A small number of fibres then lie beside the nerve of the seventh pair in ascending towards the origin of that nerve, where, in our opinion, they constitute a large portion of the great petrosal nerve—that which has at its origin the ganglion. Other fibres descend, on the contrary, in following the proper fibres of the facial nerve, and are lost among these; but the largest number cross that nerve and continue their course in the substance of the temporalis muscle, to be chiefly distributed to the membrane lining the internal auditory canal.

Course and relations.—Beyond the jugular ganglion, the trunk of the pneumogastric remains intimately allied with the spinal accessory for about $\frac{4}{5}$ of an inch; these two nerves then separate to allow the great hypoglossal nerve to pass between them; after which the pneumogastric nerve descends alone behind the guttural pouch, in proximity to the superior cervical ganglion.

Near the origin of the occipital artery it crosses to the inner side of that vessel, and beyond this it is joined in the most intimate manner to the cervical portion of the sympathetic chain; the single cord resulting from this fusion follows the common carotid artery, above which it is situated, to near the entrance of the thorax. The two nerves then resume their reciprocal independence, the pneumogastric penetrating the thorax a little below the sympathetic, in passing among the lymphatic glands lying between the two first ribs.

In this course, the two pneumogastrics have nearly the same relations; though there is something special connected with the left, which is related to the œsophagus towards the lower part of the neck.

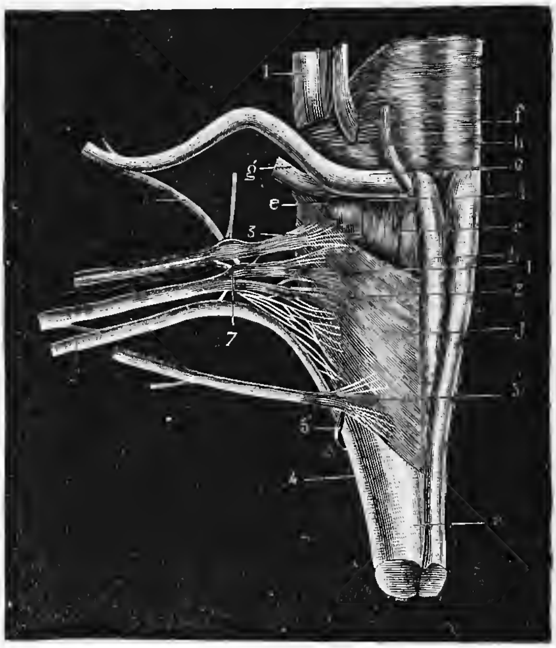
Within the chest, however, these two nerves comport themselves a little differently. The right passes round the axillary artery very obliquely, upwards, outwards, and backwards beneath the mediastinal pleura, to follow the external face of the trachea to above the origin of the bronchi, where this nerve terminates. The left also passes below the brachial trunk; but instead of turning round the trachea, it merely lies beside that tube, and reaches the root of the lung, after crossing, outwardly, the origin of the two aortæ.

When these nerves arrive above the bifurcation of the trachea, they terminate by forming the *bronchial plexus and œsophogeal nerves*—the latter being prolonged to the stomach and the solar plexus.

Beneath the jugular ganglion, but in the upper part of the neck, the pneumogastric receives filaments from the spinal accessory, ganglion of Andersch, sympathetic, hypoglossal, and the two first cervical. These different nerves cross each other in a very complex manner on the surface of the guttural pouch, the pharynx, and divisions of the carotids, and form the guttural, pharyngeal, and cartoid plexuses.

Distribution.—The branches furnished by the pneumogastric on its course are :

Fig. 456.



ORIGIN OF THE NERVES ARISING FROM THE MEDULLA OBLONGATA, AND PARTICULARLY THAT OF THE PNEUMOGASTRIC, SPINAL ACCESSORY, HYPOGLOSSAL, AND GLOSSO-PHARYNGEAL.

a, Medulla oblongata; *b*, pyramids; *c*, enlargement simulating the olivary body; *d*, lateral posterior fissure; *e*, fissure limiting, superiorly, the respiratory tract of Ch. Bell; *f*, corpus restiforme; *g*, auditory nerve; *h*, external oculo-motor; *i*, trigeminus; *j*, arciform fibres of the medulla oblongata. 1, Pneumogastric; 2, spinal accessory, inner root; 3, glosso-pharyngeal; 4, spinal accessory, medullary column; 5, inferior, or anterior, root of the great hypoglossal; 5', its ganglionic root; 6, facial nerve; 7, jugular ganglion; 8, anastomosis of the pneumogastric with the facial; 9, ramuscule from the external branch of the spinal accessory passing to the pneumogastric. (From Toussaint's Thesis on the *Anatomie Comparée du Nerf Pneumogastrique.* Lyons: 1869).

1. *Communicating filaments with the superior cervical ganglion.*
2. *Pharyngeal branch.*
3. *Superior laryngeal nerve.*
4. *Communicating filaments with the inferior cervical ganglion.*
5. *Inferior laryngeal nerve.*
6. *Cardiac filaments.*

We will pass in review these collateral divisions before studying the terminal branches, which are :

1. Those forming the *bronchial plexus.*
2. Those constituting the *œsophageal nerves.*

COLLATERAL BRANCHES OF THE PNEUMOGASTRIC NERVE.—1. **Filaments of the ~~Inferior~~ Superior Cervical Ganglion.**—Always very slender, these sometimes come from the pharyngeal ramuscule.

2. **Pharyngeal Nerve** (Fig. 459, 15).—Originating from the pneumogastric nerve at the middle part of the superior cervical ganglion, the pharyngeal passes forwards and downwards on the side of the guttural pouch, and gains the upper face of the pharynx, where it terminates in forming a plexus with the pharyngeal branch of the ninth pair. This is a sensory-branch. It gives off a large division that passes backwards to the surface of the middle and posterior constrictor muscles, to which it gives branches, and, throwing off a filament to the external laryngeal nerve, reaches the commencement of the œsophagus; it descends on the outside of that tube, by becoming distributed in its muscular tunic. This division—which we have named the *œsophageal branch of the pharyngeal nerve*—may be traced on the œsophagus to the lower part of the neck, and in some subjects even into the thoracic cavity.

3. **Superior Laryngeal Nerve** (Fig. 458, 1).—More voluminous than the preceding, and arising a little lower, this nerve follows an analogous course to reach the side of the larynx, where it enters the aperture below the appendix of the superior border of the thyroid cartilage, to be almost entirely expended in the laryngeal mucous membrane, which it endows with a very exquisite degree of sensibility.

At the inner face of the thyroid cartilage, it has several branches that are directed forward, upward, and backward. The first pass to the mucous membrane at the base of the tongue and the two surfaces of the epiglottis. The second are distributed in the lateral walls of the pharynx. Of the third, some go to the mucous membrane of the arytænoid cartilages and that of the œsophagus; while others descend on the thyro-arytænoid and lateral crico-arytænoid muscles, to unite with the branches coming from the recurrent, and form an anastomosis analogous to the *anastomosis of Galien* (Fig. 458, 5).

Before penetrating the larynx—and even very near its commencement—it furnishes a motor filament to

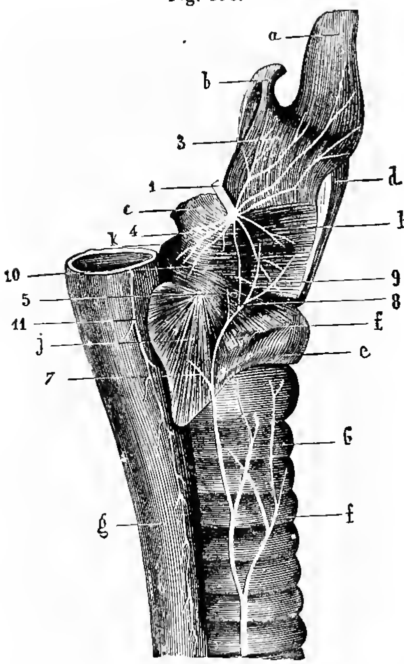
Fig. 457.

ORIGIN AND DISTRIBUTION OF THE EIGHTH PAIR OF NERVES IN MAN.

1, 3, 4, Medulla oblongata; 1, corpus pyramidale of one side; 2, pons Varolii; 3, corpus olivare; 4, corpus restiforme; 5, facial nerve; 6, origin of glosso-pharyngeal nerve; 7, ganglion of Andersch; 8, trunk of the nerve; 9, spinal accessory; 10, ganglion of pneumogastric; 11, its plexiform ganglion; 12, its trunk; 13, its pharyngeal branch, forming the pharyngeal plexus, 14, assisted by a branch from the glosso-pharyngeal, 8, and one from the superior laryngeal, 15; 16, cardiac branches; 17, recurrent laryngeal branch; 18, anterior pulmonary branches; 19, posterior pulmonary branches; 20, œsophageal plexus; 21, gastric branches; 22, origin of the spinal accessory nerve; 23, its branches distributed to the sterno-maxillaris and mastoido-humeralis; 24, its branches to the trapezius muscle.

the crico-pharyngeal and crico-thyroid muscles. This filament either arises directly from the pneumogastric nerve, or—as is most frequently the case—from the pharyngeal ramuscule; this is the *external laryngeal* nerve of anthropotomists (Fig. 458, 8). The external laryngeal receives accessory branches from the superior cervical ganglion, the œsophageal branch, and the pharyngeal nerve, and is then distributed to the muscular tunic of the œsophagus. It is to the union of this branch with the œsophageal branch of the pharyngeal nerve, that we have given the name of *superior œsophageal nerves*.[1]

Fig. 458.



DISTRIBUTION OF THE NERVES IN THE LARYNX OF THE HORSE.

a, Base of the tongue; *b*, epiglottis; *c*, arytænoid muscles; *d*, section of the thyroid cartilage to show the parts it covers; *e*, cricoid cartilage; *f*, trachea; *g*, œsophagus; *h*, thyro-arytænoid muscle; *i*, lateral crico-arytænoid muscle; *j*, posterior crico-arytænoid muscle; *k*, arytænoid muscle. 1, Superior laryngeal nerve; 2, inferior laryngeal; 3, branches of the superior laryngeal passing to the epiglottis and tongue; 4, branches of the superior laryngeal passing to the œsophagus; 5, very fine multiple anastomoses between the two laryngeals; 6, tracheal branches; 7, branch to the posterior crico-arytænoid muscle (a portion is distributed, through the muscles, to the subjacent mucous membrane); 8, branch to the lateral crico-arytænoid muscle; 9, branch to the thyro-arytænoid muscle; 10, branch passing to the arytænoid muscle; 11, œsophageal branch of the pharyngeal nerve (it sometimes comes from the external laryngeal). (From Toussaint's work.)

4. **Communicating Filaments with the Inferior Cervical Ganglion.**—These do not always directly enter this ganglion, for when the middle cervical ganglion exists they pass to it. They are not similarly disposed on both sides. The filaments of the right pneumogastric, two or three in number, are extremely short, though voluminous. The left pneumogastric usually only furnishes a single, long, thin ramuscule, which is detached in the region of the neck near the point where the pneumogastric commences to separate from the cervical branch of the sympathetic, and reaches the inferior cervical branch of the sympathetic, and reaches the inferior cervical ganglion by remaining alongside the principal nerve.

5. **Inferior Laryngeal Nerve** (Figs. 458, 2; 480, 27, 28).—Also named the *recurrent*, or *tracheal recurrent*, because of its disposition. It begins in the thoracic cavity, and ascends along the trachea to the larynx, the intrinsic muscles of which it stimulates, with the exception of the crico-thyroid.

The two recurrent nerves are not quite symmetrical at their origin. That of the right side is detached from the pneumogastric below the axillary artery, near the dorso-cervical artery. It is immediately reflected forward in embracing the origin of that vessel, which it crosses inwards to be placed against the trachea, in the middle

[1] Toussaint has seen this branch leave the œsophagus to lie beside the recurrent; but its filaments always return to that tube as ascending twigs.

of the principal cardiac nerves, with some of which it contracts intimate relations.

On the left side, it is only when the pneumogastric nerve arrives near the root of the lung that it gives off its recurrent. To be reflected forward, the latter turns from left to right behind the arch of the aorta, and arrives beneath the inferior face of the trachea, among the cardiac nerves, with which it communicates, like the right.

The inferior laryngeal nerves are in this way mixed, at a greater or less distance from their commencement, with those branches of the sympathetic (see the description of the *sympathetic*) which collectively constitute the tracheal plexus. They are soon disengaged, however, and leave the chest, but always in proceeding along the inferior face of the trachea, then ascending on its sides, below the carotid arteries, which they gradually approach, and finally attain the larynx in penetrating beneath the crico-pharyngeal muscle.

According to Goubaux, the left recurrent must be situated more superficially than the right in the lower part of the neck, and for this reason should be more exposed to compression. He thus explains why, in chronic "roaring," the alterations observed are nearly always in the left muscles of the larynx.

The terminal divisions of the recurrents are distributed to the posterior and lateral crico-arytænoid, and the arytænoid and thyro-arytænoid muscles, as well as to the subglottic mucous membrane.

In their long course, they emit collateral ramuscules that also ascend, and are distributed to the mucous membrane and muscular layer of the trachea, as well as to that of the œsophagus.[1]

The *recurrent œsophageal ramuscules* are all sensitive, and form five groups: the first and second arise, on the left side, close to the arch of the aorta, ascend on the sides of the trachea, and pass to the portion of the œsophagus lying between that tube and the thoracic section of the longus colli muscle. The third, more considerable, springs from a branch given off at the brachial trunks; it is markedly recurrent, and forms on the side of the trachea, with the second, a small plexus, and then lies closely alongside the œsophagus, which it accompanies for a distance of eight inches from the first rib. The branch constituting the fourth group is the longest of all; it is detached about two or two and a half inches in front of the first rib, and after emitting several long tracheal filaments, it ascends on the side of the trachea, close to the border of the œsophagus, where it generally disappears at about six or eight inches from the pharynx. The fifth group is composed of a branch detached from the recurrent, about the point where the preceding terminates; it goes entirely to the origin of the tube.

6. **Cardiac Filaments.**—These will be alluded to when describing the sympathetic nerves.

TERMINAL BRANCHES OF THE PNEUMOGASTRIC NERVES. 1. **Bronchial Plexus** (Fig. 480, 29).—The bronchial plexus is formed by several branches from the pneumogastric, on the arrival of that nerve above the roots of the lungs; these interlace into a network and ramify around the bronchi, following these into the texture of the lungs. It is these branches which give to the mucous membrane its great sensibility, and which provoke those evident contractions of which the bronchioles are the seat.

2. **Œsophageal Branches** (Fig. 480, 30, 31).—After emitting the ramus-

(1 For a detailed description of the superior and inferior laryngeal nerves, see my treatise on "*Roaring in Horses.*" London: 1889.)

cules of the bronchial plexus, each pneumogastric is continued along the œsophagus by two branches—a superior and inferior—making four branches for the two nerves. The two superior lie together, and form a single cord, either immediately or after a certain course; the two inferior comport themselves in the same manner with one another—making a double anastomosis, from which arise the two nerves we are about to describe, and which are designated the *œsophageal nerves*, because of their situation. The right nerve forms a large portion of the superior cord; the left, especially, gives ramuscules to the inferior.

Placed between the layers of the posterior mediastinum, these two nerves follow the œsophagus for a certain distance—one above, the other below—giving off some ramuscules to that muscular tube, detaching one or two communicating branches, and traversing the foramen sinistrum in the diaphragm to enter the abdominal cavity.

The *inferior* terminates in the parieties of the stomach, by forming on the small curvature, to the right of the cardia, a very rich pre-stomachal plexus, which throws the majority of its ramuscules on the right sac of that viscus.

The *superior* passes to the left of the œsophageal insertion, along with the gastro-pulmonary artery, and is lost in the solar plexus, after giving off numerous divisions on the left sac of the stomach, mixing with the sympathetic ramuscules that encircle the gastric artery, and anastomosing around the cardia with those of the inferior cord. It is very difficult to follow the filaments of this cord from the pneumogastrics after their arrival at the solar plexus; we nevertheless observe some of them passing to the liver, others accompanying the sympathetic branches that come from the solar to the posterior mesenteric plexus in following the small mesenteric vein; and no doubt others find their way among the filaments of the trisplanchnic nerve, which proceed with the anterior mesenteric artery.

Functions of the Pneumogastric.—Formed by the two orders of fibres, the pneumogastric is a sensory-motor nerve, and the seat of reflex currents which make it play a very important part in several acts of vegetative life, and bring it into relationship with the great sympathetic nerve, with which we have seen that the tenth pair maintains anastomotic connections in several points of its course.

It is the pneumogastric nerve that gives to the mucous membrane of the larynx the exquisite sensibility it enjoys.

It stimulates the motor muscles of the larynx to movement.

To it is also due the sensibility of the broncho-pulmonary mucous membrane.

It causes contractions of the muscular fibres in the broncho-tracheal passages—contractions which are involuntary, and due to reflex influence.

It also causes movements of the œsophagus and the stomach, which are involuntary and due to reflex currents.

Perhaps it acts in an analogous manner—by reflex action—in the secretion of the gastric fluid and the functions of the liver; but these are points which science has not yet determined.

It appears proved that it exercises an influence on the essential phenomena of respiration (Laulanie), as it participates in the centripetal stimulation which brings the respiratory mechanism into play.

It transmits to the heart the influence of the moderating centre of that organ which is situated at its roots in the medulla oblongata.

After its section in the region of the neck, the movements of the heart become very precipitate, and we may diminish the force of these movements, or even completely arrest them, by galvanizing the peripheral end of the nerve. In this action on the heart, one nerve, usually the right, plays a predominant part (Arloing and Tripier).

It also transmits to the bulbar vaso-motor centres, through the medium of the *depressor nerve of the circulation—Cyon's nerve*—which forms part of it, a stimulus that leaves the heart and produces a general vaso-dilatating effect—chiefly, however, in the abdominal cavity.

11. Eleventh Pair, Spinal Accessory Nerves, or Accessory Nerves of the Pneumogastrics (Fig. 456, 2, 4).

The spinal accessory is an exclusively motor nerve, which, at its exit from the cranium, is so intimately connected with the pneumogastric, that we might perhaps follow the example of Müller, and describe the two as forming one and the same pair.

Origin.—This nerve exhibits a singular disposition, in that it arises from the whole extent of the cervical spinal cord, and ascends in the spinal canal to near the pneumogastric, with which it leaves the cranium by the posterior part of the foramen lacerum. It is also described as a cranial nerve, in consequence of the latter peculiarity; but from its origin it is rather a spinal nerve, a fact which is sufficiently indicated by the name generally given to it.

In the interior of the spinal canal, it is a long cord measuring from 27 to 31 inches in middle-sized animals. It commences, by a very fine point, at the cervical or brachial enlargement of the spinal cord, follows that organ in an ascending course, lying close to its lateral column, and passing between the roots of the two orders of cervical nerves until it arrives at the medulla oblongata, where it is inflected outwards at the foramen lacerum posterius, into which it passes to leave the cranium.

In this ascending course it gradually increases in volume, as it at intervals receives additional filaments from the lateral column of the spinal cord, like the radicular extremity of the nerve itself. Traced into the spinal cord, the radicular filaments are found to arise from a nucleus situated outside the base of the inferior cornua. Before making its escape from the cranium, it receives, besides, some of the posterior or motor roots of the pneumogastric nerve. In the foramen lacerum, it becomes applied against the ganglion (jugular) of that nerve, in the manner of motor fibres of mixed nerves, and gives it some of its own filaments, while it also receives others.

The long cord here described as the root of the spinal accessory, is considered by some authorities as only a portion of this nerve, to which they give the name of *external* or *medullary root of the spinal accessory*. They designate as the *internal* or *bulbar root* of that nerve, the anastomosing filaments already described as the motor roots of the pneumogastric. According to them, this internal root only lies beside the pneumogastric for a very short distance, ultimately leaving it and forming the superior laryngeal and pharyngeal nerves, which seem to arise from the vagus rather than from the accessory of Willis.

Distribution.—Beyond the ganglion of the pneumogastric, the spinal accessory nerve remains beside the trunk of the pneumogastric for scarcely an inch; it then separates from it at an acute angle, the sinus of which is occupied by the great hypoglossal nerve, is directed backwards, passing beneath the superior extremity of the maxillary gland and mastoido-humeralis muscle, gains the supero-posterior border of that muscle, and follows it to the front of the shoulder.

Here it slightly ascends, crosses that region below the inner face of the cervical trapezius, and is distributed to the dorsal trapezius.

On its passage it emits : 1. One or two thick filaments to the superior cervical ganglion, proceeding from the spinal accessory by a small plexiform network, where the nerve separates from the pneumogastric. 2. Near the maxillary gland, a thick branch to the sterno-maxillaris muscle. 3. Slightly beyond this, another branch destined to the anterior portion of the mastoido-humeralis. 4. A series of ramuscules to the cervical trapezius.

In its course, the spinal accessory traverses the anterior part of the superficial cervical plexus, and receives additional ramuscules from the first, second, third, fourth, fifth, and sometimes even from the sixth cervical nerves.

Reduced to its medullary root, as has been described, the spinal accessory stimulates the muscles to which it is distributed, and through them has a share in expiration. By the contraction of these muscles, the ribs may be maintained raised for a certain period, and cause the air to be slowly expelled ; also allowing the sounds or voice produced by its passage through the larynx to be modulated. Crowing is no longer possible in Birds when the medullary root of the spinal accessory has been divided, as has been demonstrated by Bernard.

12. Twelfth Pair, or Hypoglossal Nerves (Figs. 171, 22 ; 456, 5 ; 459, 10).

The *hypoglossal* nerve is exclusively motor, and stimulates the muscles of the tongue.

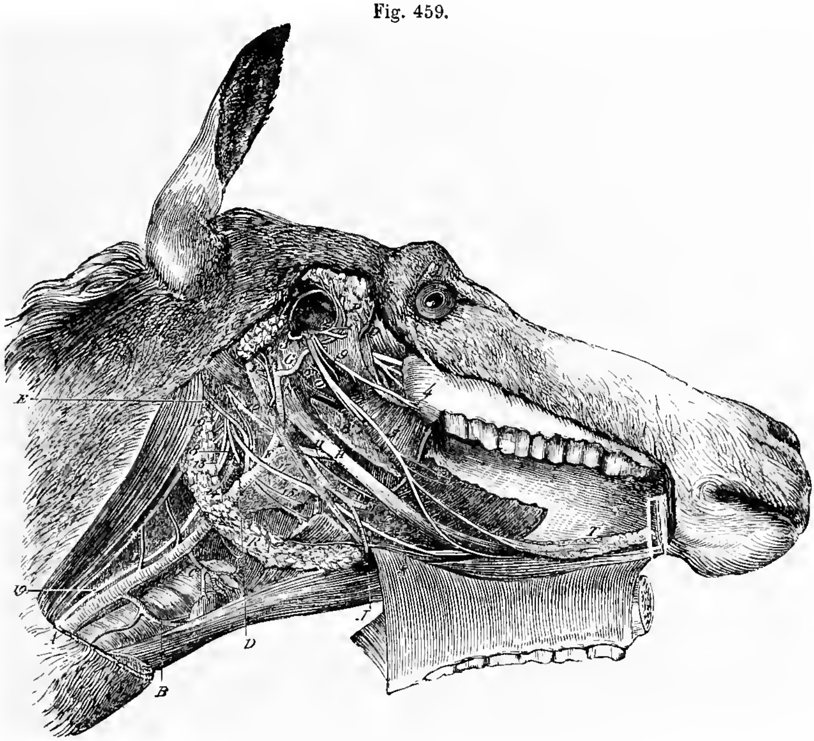
Origin.—It apparently arises from the lower face of the medulla oblongata, on the prolongation of the line of origin of the inferior spinal nerves, by a dozen converging filaments. Traced into the medulla, these filaments are found to pass into a principle nucleus situated near the point where the central canal of the spinal cord enlarges to form the floor of the fourth ventricle, inside the pneumo-spinal nucleus, and in the small masses of grey substance placed below and outside the preceding, named the *accessory nucleus.*

The roots of the hypoglossal nerve pass through the dura mater in two or three bundles, which enter the condyloid foramen of the occipital bone, where they unite to form a single cord. The hypoglossal has also a ganglionic root which Toussaint constantly found in the Ass, Mule, Ox, and Dog, and which had been previously seen by Meyer and Vulpian. The ganglion of the hypoglossal in the Horse is fusiform, and the size of a small lentil (Fig. 456, 5′). It is sometimes absent.

Distribution.—The hypoglossal nerve, thus constituted, immediately after its departure from the condyloid foramen, communicates with the first cervical pair by means of a transverse ramuscule ; it then passes between the spinal accessory and pneumogastric nerves, descends on the external face of the guttural pouch, where it is connected with the superior cervical ganglion of the sympathetic by numerous filaments, which in great part form the plexiform network called the "guttural plexus." The nerve afterwards crosses to the outside of the external carotid artery, in proceeding forward and downward on the side of the pharynx and larynx, receiving at that point a slender ramuscule from the first cervical ; it then passes within the inferior extremity of the stylo-hyoid muscle and the submaxillary artery, which it crosses very obliquely, is prolonged between the mylo-hyoid and great hyo-glossus muscles, sends numerous small filaments to the latter and a ramuscule to the genio-hyoideus, and finally terminates in a series of branches analogous to those of the gustatory nerve, and which mix with them.

These branches are therefore reflected upwards, bending round the posterior

Fig. 459.



DEEP NERVES OF THE HEAD IN THE MULE.

1, Superior maxillary nerve at its exit from the foramen lacerum; 2, masseteric nerve; 3, subzygomatic nerve; 4, buccal; 5, lingual or gustatory nerve; 6, chorda tympani; 7, inferior maxillary nerve, cut near where it enters the maxillo-dental canal; 8, mylo-hyoideus nerve; 9, pterygoid nerve; 10, glosso-pharyngeal nerve; 11, its pharyngeal branch; 12, its lingual branch; 13, pneumogastric nerve; 14, superior laryngeal branch of that nerve; 15, its pharyngeal branch; 16, spinal accessory of Willis; 17, hypoglossal nerve; 18, origin of the cervical cord of the great sympathetic; 19, the same after its union with the pneumogastric. *A*, Common carotid artery; *B*, accessory thyroid artery; *C*, thyro-laryngeal artery; *D*, origin of the internal carotid artery (the vessel is concealed by the guttural pouch); *E*, occipital artery; *F*, external carotid artery; *G*, internal maxillary artery; *H*, pharyngeal artery (drawn too large); *I*, submaxillary artery; *J*, lingual artery; *K*, origin of the maxillo-muscular artery; *L*, posterior auricular artery; *M*, trunk or origin of the superficial temporal artery; *O*, inferior dental artery; *P*, posterior deep temporal artery; *Q*, anterior deep temporal artery; *R*, maxillary gland; *S*, Wharton's duct; *T*, sublingual gland. The letter *N* placed at the upper end of the large cornu of the hyoid bone has no signification.

border of the great hyo-glossus, and pass into the interstice between that muscle and the genio-glossus. They are distributed to all the muscles of the tongue.

The hypoglossals, being motor nerves, cause the contraction of the muscles of the tongue during the movements proper to mastication and the production of the voice. Though they most frequently act together, yet they may do so separately, as in the unilateral movements of the tongue.

Differential Characters in the Cranial Nerves of the other Animals.

In the domesticated Mammals, the cranial nerves offer the greatest analogies; their origin is the same in all, and it is only in their distribution that we find some variety, due to the difference in the form of the head. Consequently, in this comparative analysis we shall not discover any fundamental differential characters.

RUMINANTS.—There is no difference to note in the *four first pairs*.

Trigeminal nerve.—Divided into three branches as in Solipeds. It has been stated that in Ruminants the ophthalmic branches are distributed to the majority of the muscles of the eye; in the **Sheep**, we have only seen the *palpebro-nasal* nerve offering this relationship to the motor organs of that part. The *anterior palatine* nerve is relatively voluminous.

In the **Ox** and **Sheep**, the buccal nerve furnishes the excito-secretory nerve of the parotid gland; it is inflected on the anterior border of the masseter, and follows Steno's duct, in both species, to reach the gland. It is often formed by two parallel filaments (Moussue). A filament of the inferior branch of the buccal nerve which goes to the molar gland, is also excito-secretory (Moussu).

Facial nerve.—Towards the middle of its subparotideal course, this gives off a large *anterior auricular nerve;* when it arrives at the middle of the posterior border of the masseter muscle, it divides into two branches. The *inferior branch* passes obliquely downwards and forwards, towards the mental foramen, where it terminates as in the Horse; it furnishes an anastomotic branch to the *superior*. The latter crosses the middle portion of the masseter, and becomes mixed with the suborbital ramuscules of the fifth pair; about the middle of its course it receives a filament from the superficial temporal nerve. We need not allude to the *auditory* and *glosso-pharyngeal nerves*, except to say that the latter communicates with the pneumogastric soon after its exit from the foramen lacerum.

Pneumogastric nerve.—This offers numerous differences in its roots and distribution.

In the **Ox** and **Sheep**, the *sensitive roots* arise from an irregularly elliptical surface comprising the whole of the respiratory tract. They are from fifteen to twenty in number, and often join each other; they may divide into three principal fasciculi arising at slight distances.

The *motor roots* are a little larger than in the Horse; before joining the sensitive roots they are confounded in a small ganglion that pertains to them.

The *jugular ganglion* is voluminous, but apart from this it presents the same features as in the Horse, receiving all the proper roots of the pneumogastric and internal root of the spinal accessory, and even those which are united in their own ganglion. The portion of the ganglion that is more especially formed by the roots of the spinal accessory is rather an intrication of nerve-fibres than a real ganglion; it is impossible by the most minute dissection to separate it from the rest of the ganglion.

The jugular ganglion also receives a division of the glosso-pharyngeal, and it gives one to this nerve and the external branch of the spinal accessory.

The pneumogastric nerve, in the *guttural portion*, is much larger than in the Horse. This peculiarity is noticeable throughout its whole extent, and is indicated at its roots.

The ganglionic plexus is absent in the **Ox.** The course and relations of the nerve in this portion, are analogous to those observed in Solipeds.

The *pharyngeal* nerve is voluminous, and the branch it sends to the œsophagus is the largest of its divisions: this branch passes backwards to the surface of the constrictors of the pharynx, joins the external laryngeal, gives a large branch to the thyro-pharyngeus, and is insinuated on the sides of the œsophagus, between it and the thyroid gland; there it divides into two portions, one of which descends on the sides of the œsophagus, where it forms a very rich plexus with the branches from the inferior laryngeal, while the other is lost immediately in the recurrent nerve at the thyroid gland.

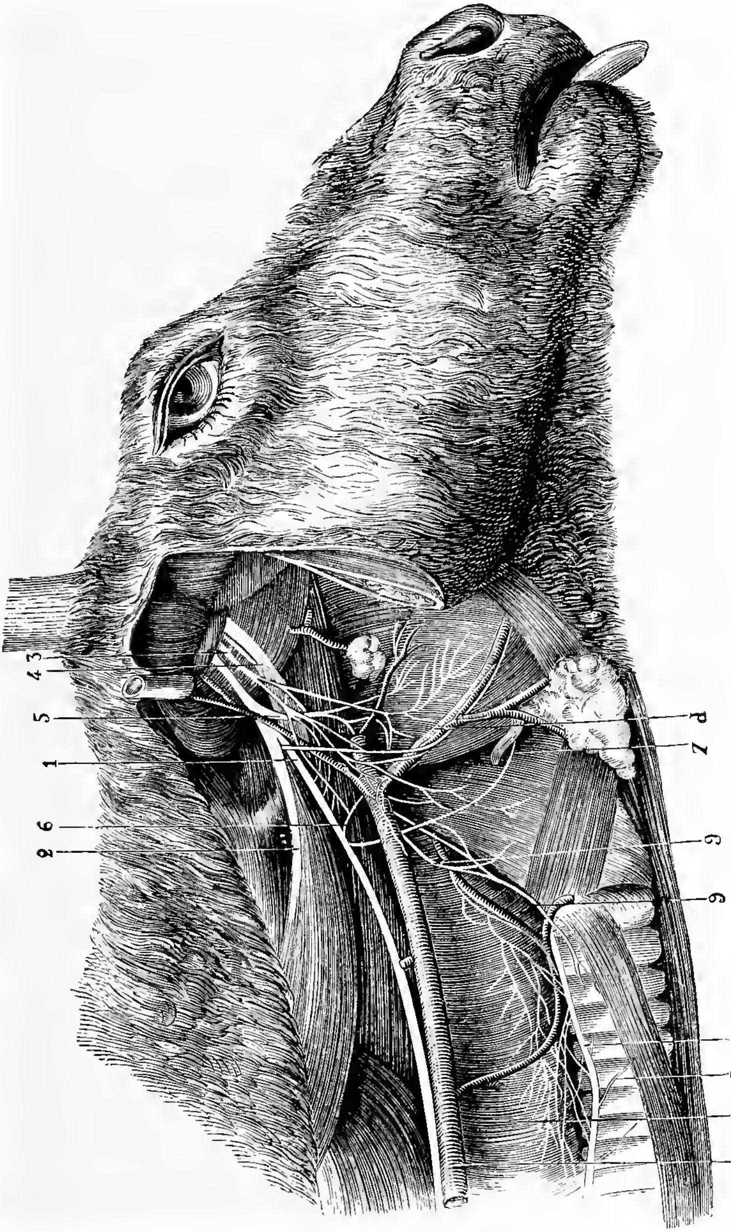
The *external laryngeal* arises at a short distance above the superior laryngeal, where it receives a large branch from the glosso-pharyngeal and another from the sympathetic, and immediately passes alongside the œsophageal branch of the pharyngeal nerve. With a little attention, we may dissect a fasciculus coming from the external laryngeal and passing to the crico-thyroid muscle, and the thyroid gland and its vessels, after receiving a branch from the superior laryngeal. In the **Sheep,** the external laryngeal sometimes gives a branch to the œsophagus, and which anastomoses with the inferior laryngeal, or descends on the side of the tube, conjointly with the œsophageal branch of the pharyngeal.

The *superior laryngeal* rises below the preceding; it is very voluminous, and communicates with the sympathetic, either directly or through the medium of the guttural plexus, and with the pharyngeal nerves and external laryngeal. Beneath the thyroid cartilage, a large division anastomoses with the inferior laryngeal, and is finally lost in that nerve below the larynx. It is easily seen that this branch gives, in the cervical region, a great number of filaments to the œsophagus and trachea.

With the exception of some insignificant peculiarities, the pneumogastric comports itself in the *cervical and thoracic regions* as in the Horse.

The *recurrents* arise as in Solipeds, but their relations are somewhat different in the cervical region. They are placed in the channel formed by the trachea and œsophagus, and are

Fig. 460.



NERVES OF THE GUTTURAL REGION IN THE OX.

a, Œsophagus; *b*, trachea; *c*, common carotid artery; *d*, glosso-facial artery. 1, Pneumogastric nerve; 2, spinal accessory; 3, glosso-pharyngeal; 4, great sympathetic and cervical ganglion; 5, pharyngeal nerve; 6, external laryngeal; 7, superior laryngeal; 8, inferior laryngeal; 9, 9, œsophageal branches of the pharyngeal and external laryngeal.

separated from the carotid artery and the cord common to the sympathetic and pneumegastric by the very great width of the œsophagus. Their distribution to the muscles of the larynx takes place as in the Horse; the only noteworthy feature is the anastomosis of the nerve, end to end, with the superior laryngeal. In the whole of its cervical portion, the branches to the œsophagus are more numerous and voluminous than in Solipeds, although they all have the same physiological office, except those that are derived from the branch of the superior laryngeal, which are motor.

The differences remarked in the nerve in the *abdominal cavity*, are in relation to the volume and form of the stomach and its compartments.

The following is what we have observed in the **Sheep**:—

After receiving a large filament from the superior cord, the *inferior œsophageal nerve* divides into three principal branches: one passes to the left, furnishing nerves to the anterior face and greater curvature of the reticulum and the upper border of the rumen; a median, which is distributed to the anterior face of the psalterium, reaches the substance of the mesentery, follows the abomasum, to which it sends some filaments, and finally anastomoses with the retrograde nerves coming from a rich plexus that exists on the posterior face of the liver and gall-bladder; it forms, conjointly with the divisions of the solar plexus and superior œsophageal nerve, a rich plexus, from which arise branches to the liver, abomasum, and duodenum.

The *superior œsophageal nerve* is chiefly distributed to the rumen. Before reaching the stomach, it gives several divisions to the plexus already mentioned—and which might be named the "hepatic plexus"—receives a large branch from the solar plexus, and sends to it a smaller one. It afterwards divides into two principal branches, the largest of which passes along the superior fissure of the rumen, along with the vessels of that organ. According to Lavocat, this branch forms a large plexus there, which has in its centre a ganglionic enlargement, whence emanate the ramuscules that go to the whole of the upper face, sides, and lower surface of the rumen. In the Sheep we have not found a ganglion, but this does not prevent this branch from being distributed to all the parts indicated by Lavocat.

The other branch is very large, and situated in the omentum until it arrives at its convex border, when it leaves it to be distributed to the left side of t e abomasum; while the analogous nerve from the inferior œsophageal passes more especially to the right face.

In the **Camel**, the *pneumogastric* gives off, near the point where it joins the cervical branch of the sympathetic, a very remarkable branch. This is somewhat plexiform at its origin, and directly furnishes a certain number of *pharyngeal filaments*, the *superior laryngeal nerve*, and, a little lower, the *inferior laryngeal nerve*, forming a slight arch where it curves to ascend; it then descends along the œsophagus into the thorax, giving filaments to that tube and to the trachea. When it reaches the second dorsal vertebræ, this branch unites, below the œsophagus, with that of the opposite side. The single branch resulting from this union runs between the trachea and œsophagus, and ends by dividing into several filaments that enter the bronchial plexus.

For the whole of its cervical course, the pneumogastic lies close beside the sympathetic and does not give off any ramuscles worthy of note. After separating from the sympathetic at the entrance to the chest, it passes into that cavity alongside the trachea to the commencement of the bronchi; there it forms, with its congener of the opposite side, the *broncho-œsophageal plexus*, which is extremely remarkable, and is prolonged behind by the *œsophageal nerves* —similar to those in the Horse. The pneumogastric does not appear to directly furnish filaments to the inferior cervical ganglion.

Spinal accessory.—The origin of this nerve offers slight differences, which we have indicated in speaking of the motor roots of the pneumogastric. With regard to its distribution in the **Ox**, it offers the following features: At the inferior extremity of the transverse process of the atlas, it divides into two branches—a superior and inferior. The first is a little larger than the spinal accessory of the Horse, and comports itself as in that animal. The inferior branch is directed downward and backward, traverses the muscle we have named the sterno-suboccipital (see *Myology*), beneath a tendon that runs across the muscular fibres, and arrives between that muscle and the sterno-maxillaris. At this point it separates into a certain number of ramuscules, the first three or four of which are slightly recurrent, and enter the upper part of the sterno-maxillaris; the others are large and directed towards the sternum, to be distributed to the latter muscle, or to it and the sterno-suboccipitalis.

These branches of the spinal accessory represent the branch which, in the Horse, passes exclusively to the sterno-maxillaris. In reflecting on the distribution they offer in the Ox, we are brought to the conclusion that the sternal band, which has been described as belonging to the first, forms, with the sterno-suboccipitalis, one and the same muscle—the analogue of the sterno-maxillaris or sterno-mastoideus of Solipeds. These two muscular fasciculi are, otherwise, closely attached to each other, if not confounded near their origin at the anterior prolongation of the sternum.

Lastly, the *hypoglossal nerve*, before crossing the pneumogastric, communicates with the first cervical by a considerable branch; lower, it gives off a long ramuscule that descends on the carotid artery.

PIG.—We need not refer to the *olfactory*, *optic*, or *motores oculorum*, neither to the *glosso-pharyngeal*, as what has been said about them in Solipeds holds good in this animal.

Trigeminal nerve.—This also divides into three principal branches. The palpebro-nasal ramuscule of the *ophthalmic branch*, anastomoses with a motor nerve of the eye on the deep face of the external rectus muscle. The *superior maxillary nerve* leaves the cranium by the great sphenoidal slit, and immediately enters the superior dental foramen; its orbital course is therefore very short.

Its *spheno-palatine branch* passes at once below the alveolar tuberosity, where it divides into several ramuscules: one, entering the palatine fissure, forms the *posterior palatine nerve;* the others pass into the palatine arch at various distances, to constitute the *middle palatine nerves;* some of them even enter the palatine canal with the *anterior palatine* or *palato-labial nerve.*

Facial.—Beneath the parotid gland, this divides into several branches, of which there are three principal. One is directed upwards, and passes in front of the ear; this is the smallest. The second proceeds forward, crosses the masseter near the zygomatic process, unites with the inferior branch, and is expended among the suborbital ramuscules of the superior maxillary. The third passes downward and forward, under the parotid gland, arrives in the intermaxillary space, is inflected in front of the masseter to become superficial, and terminates with the middle branch. Towards the maxillo-labialis muscle, this inferior branch gives off a ramuscule to the lower lip.

Pneumogastric.—This joins the sympathetic near the upper third of the neck, and at its point of union offers a greyish enlargement resembling the gangliform plexus of Man. As far as the origin of the œsophageal nerves, the pneumogastric of the **Pig** resembles that of the Horse. The latter is voluminous, and does not divide into two branches immediately beyond the bronchial plexus, but at some distance from it. Numerous anastomoses exist between the two œsophageal nerves—superior and inferior. At their termination they differ much from each other in volume; the inferior is very small, and terminates on the anterior face of the stomach; the superior, much larger, partly remains at the stomach, and partly crosses the small curvature of that viscus to enter the solar plexus.

Spinal accessory.—This nerve commences and terminates as in Solipeds. After being inflected backward on the anterior border of the mastoido-humeralis, it divides into two ramuscules—a deep and superficial. The first is confounded with a cervical nerve, near the intervertebral foramen through which the latter passes; the second goes to the trapezius muscle, in which it is expended.

Near the base of the tongue, the *hypoglossal* gives off a filament that passes to the genio-hyoideus muscle.

CARNIVORA.—In these animals the majority of the cranial nerves do not offer any important differences. We will, therefore, say nothing concerning the first two pairs, or of the motores oculorum, spinal accessory, and glosso-pharyngeal, except that the motor nerves of the eye are mixed with the filament of the ophthalmic branch among the muscles of the orbit.

Trigeminal nerve.—When the branch constituting the *superficial temporal nerve*, reaches the posterior border of the maxilla, it divides into several ramuscules; one portion lies beside the middle branch of the facial, the other accompanies the anterior auricular nerve by becoming intimately united to it. We have also found, in the **Dog**, a branch that is detached from the inferior maxillary, almost immediately after its exit from the cranium. It descends into the intermaxillary space, in company with the facial artery. At the posterior border of the mylo-hyoideus muscle it separates into two ramuscules: one is applied to that muscle, and follows it to near the symphysis of the jaw; the other is inflected outwards and upwards, in front of the masseter muscle, and joins the inferior branch of the facial. Owing to this arrangement, each of the branches of the facial is provided with a sensitive ramuscule from the fifth pair.

The lingual nerve furnishes vaso-motor and excito-secretory nerves to the submaxillary and sublingual glands, as is shown in Fig. 461, borrowed from Bernard.

Facial.—At its exit from the external auditory hiatus, it divides into four branches, three of which appear to form its termination. The first—the smallest—is directed downwards across the parotid gland, and constitutes the cervical ramuscule. The other three are distinguished as superior, middle, and inferior.

The *superior branch*, the largest, ascends towards the forehead, and describes a curve with convexity upwards, turns round the orbit, and terminates near its nasal angle. In its course it furnishes: 1. An anterior auricular ramuscule. 2. Above the insertion of the masseter, several muscular filaments. 3. It is crossed, above the eye, by the superciliary filaments of the ophthalmic nerve. The *middle branch* accompanies Steno's duct to the surface of the cheek; reaching the anterior border of the masseter, it anastomoses in a very flexuous manner with the ramuscule of the inferior branch, and terminates in the upper lip and the end of the nose. The *inferior branch* passes towards the maxillary fissure; there it receives the sensitive

Fig. 461.

INNERVATION OF THE SUBMAXILLARY AND SUBLINGUAL GLANDS IN THE DOG.

a, Submaxillary gland; *c*, *c*, Wharton's duct; *i*, *k*, *g*, arteries of the gland; *b*, sublingual gland; *d*, *d*, excretory duct. 1, 1, Lingual nerve; 2, 2, its branch to the submaxillary gland.

ramuscule sent to it by the fifth pair, gives off filaments to the middle branch, and is then continued into the lower lip.

Pneumogastric.—The *sensitive roots* closely resemble, in their disposition, those in the Ox. The *motor roots* are separated into two series of filaments; the anterior unite in a small ganglion then pass into the jugular ganglion; the posterior lie beside the medullary root of the spinal accessory, but leave it to become united with the jugular ganglion.

Below the foramen lacerum, the pneumogastric nerve gives off the *pharyngeal nerve* before forming the analogue of the plexiform ganglion of Man. This plexus is better defined than in him, and is a real fusiform elongated *ganglion*, at the grey basis of which some white filaments are seen. It is situated a little farther from the cranium than the superior cervical ganglion. The ganglion itself furnishes the superior laryngeal nerve, which gives off, as in Man, the *external laryngeal* nerve.

There is nothing to indicate in the pharyngeal nerve, its disposition being absolutely the same as in the Ox.

In the **Dog**, the *superior laryngeal nerve* has a curious disposition, which has not yet, to our knowledge, been described. Reaching the inner face of the thyroid cartilage, it gives off, as in the other animals, filaments to the glottis, epiglottis, base of the tongue, and œsophagus; but the ramuscule of Galien, which nearly equals the superior laryngeal in volume, does not anastomose with the inferior laryngeal; it gives a large branch to the crico-arytænoid muscle in passing to its surface, and then leaves the larynx to the inside of the recurrent, descending on the trachea as far as the entrance to the chest. In that cavity, the descending branch of the superior laryngeal forms two divisions that communicate with the ramuscules of various other nerves passing into this region. On the right side, the largest division receives a voluminous branch from the inferior cervical ganglion; then the two divisions unite, and join the pneumogastric after it has turned round the brachial trunk, a little behind the point of emergence of the inferior laryngeal.

On the left side the same arrangement is found; the anastomoses are larger and more numerous than on the right side; the branch follows, in an inverse direction, the course pursued by the recurrent nerve, to join the pneumogastric at the part where the recurrent originates from the latter.

In this course, the branch gives large ramuscules to the œsophagus and trachea; those distributed to the former either pass along the muscular tunic and return again to the nerve, or continue along the surface of that tube. In all cases, there is found on the sides of the œsophagus a rich plexus formed by these filaments, as well as by those coming from the pharyngeal nerve.

This branch also offers other peculiarities. Thus, it is very often found alongside the laryngeal nerve for some distance, and sometimes at several points. When this happens in the upper part, at the larynx, as occurs in many cases, it appears to have an anastomosis as in the Ox; but it is always easy to separate the two nerves, even in fresh specimens, and this separation is greatly facilitated if the piece has been steeped in water acidulated by nitric acid.

In the *cervical portion*, the pneumogastric nerve is closely united to the sympathetic, the separation of the nerves being no longer possible as in the Horse and Ox.

We have already described a portion of the *inferior laryngeal* nerve, in speaking of the *tracheo-œsophageal* branch of the superior laryngeal. Comparison with other animals requires that we should transfer the latter to the recurrent. In the *Dog*, the inferior laryngeal rises by two distinct branches, a short distance from each other, on the right and left sides; these may, or may not, lie together for some distance, but they never become fused. The external part of the nerve receives at intervals filaments proceeding from the superior laryngeal branch, and it rarely gives very fine twigs to the trachea and œsophagus. The communications with the cardiac and tracheal nerves are also chiefly made by the tracheo-œsophageal branch.

The *bronchial nerves* are large and numerous.

The œsophageal plexus, which is furnished by the nerves of the same name, is larger and finer than in the Horse.

There is nothing to note particularly in the termination of the nerves in the stomach.

The *hypoglossal* gives a long branch that passes to the sides of the larynx, and enters the muscles on the anterior face of the trachea.

Rabbit.—We shall only notice some differences in the *facial* and *pneumogastric nerves*.

The *facial* gives two or three fine branches to the temporo-auricular nerve, on its sub-parotideal course. When these two nerves reach the anterior border of the parotid, they are parallel to and superposed on each other, and it is only on the middle of the masseter that the temporo-facial plexus is formed. Sometimes the branch for the *risorius of Santorini* is detached before the formation of the plexus

The *pneumogastric* has a gangliform plexus, like that of Carnivora. In the cervical region, it is isolated from the filament of the sympathetic. The Rabbit has a sensitive heart-nerve, discovered by Ludwig and Cyon, and named by them the *depressor nerve of the circulation.* It usually begins by two roots—one furnished by the pneumogastric, the other by the superior laryngeal nerve. It descends along the neck, beside the cord of the sympathetic, receives—on entering the thorax—ramuscules from the first thoracic ganglion, and is soon lost in the substance of the heart. The root from the superior laryngeal should be the largest, as Toussaint has always found it, while he has rarely seen that which is detached before the formation of the plexus.

Comparison of the Cranial Nerves of Man with those of Animals.

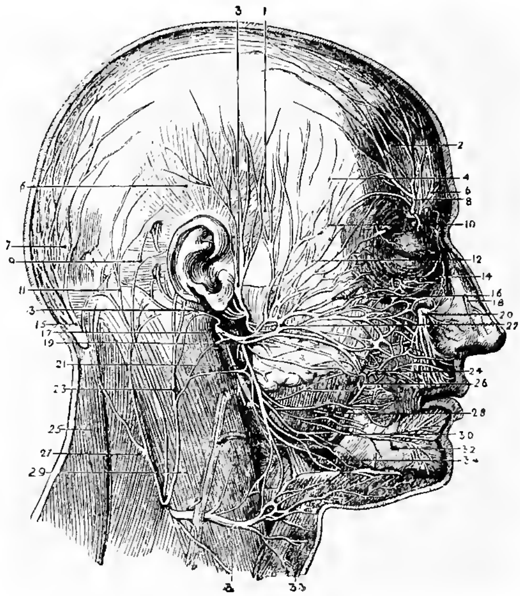
The few modifications offered by the cranial nerves of Man, when compared with those of animals, are dictated by the disposition of the parts and organs to which they are distributed.

We have spoken of the *olfactory lobes* when studying the brain, so that we need not again refer to them. The three succeeding nerves offer nothing worthy of mention.

Trigeminal nerve.—This has the same origin and divisions as in animals.

The *frontal nerve* of the ophthalmic portion divides into two branches; these are inflected upwards on the margin of the orbit, and distributed to the skin of the forehead. These two branches—well developed in the Dog—are distinguished as internal and external. The latter anastomoses with a branch of the facial. The *nasal nerve*, after spreading over the surface of the turbinated bones and the meatus, gives off a ramuscule that becomes subcutaneous in

Fig. 462.



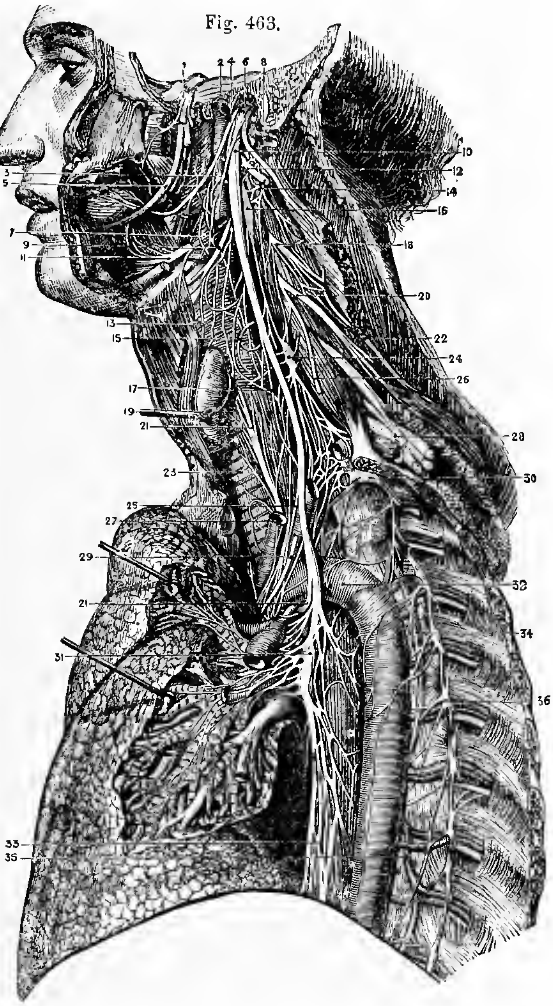
NERVES OF THE FACE AND SCALP.

1, Attrahens aurem muscle; 2, anterior belly of occipito-frontalis; 3, auriculo-temporal nerve; 4, temporal branches of facial; 5, attolens aurem muscle; 6, supra-trochlear (5th); 7, posterior belly of occipito-frontalis; 8, supra-orbital; 9, retrahens aurem muscle; 10, temporal branch of temporo-orbital; 11, small occipital; 12, malar branches of facial; 13, posterior auricular (7th); 14, malar branch of temporo-malar (5); 15, great occipital; 16, infra-orbital branches of facial; 17, facial; 18, nasal; 19, cervico-facial division of 7th; 20, infra-orbital; 21, branches of digastric and stylo-hyoid; 22, temporo-facial division of 7th; 23, great auricular; 24, buccal branches of facial; 25, trapezius muscle; 26, buccinator (5th); 27, splenius capitis; 28, masseter; 29, sterno-mastoideus; 30, supermaxillary branches of facial nerve; 31, superficial cervical; 32, mental; 33, platysma muscle; 34, submaxillary branches of facial nerve.

passing between the inferior border of the nasal bone and cartilage of the nostril; this is the *naso-lobular* nerve.

The *superior maxillary nerve* leaves the cranium by the foramen rotundum, reaches the suborbital furrow, and spreads over the face by suborbital branches. Like that of animals, it gives rise to an *orbital ramuscule*, and posterior and anterior dental branches. Differences appear in the other branches which are furnished, in animals, by the superior maxillary nerve: in Man these branches leave Meckel's ganglion. The filaments leaving this ganglion are: 1. The *pharyngeal nerve of Bock*, which is distributed in the upper portion of the mucous membrane of the pharynx, in that of the Eustachian tube, and the posterior orifice of the nasal cavities. 2. The *palatine nerves—great* or *anterior*—sent to the mucous membrane of the anterior portion of the palate; *middle palatine*, distributed to that of the soft palate, and *posterior palatine*, that goes to the two faces of the soft palate and its muscles. 3. The *nasal* or *spheno-palatine nerve.*

Fig. 463.



DISTRIBUTION OF THE EIGHTH PAIR OF NERVES ON LEFT SIDE.

1, Gasserian ganglion of 5th nerve; 2, internal carotid artery; 3, pharyngeal branch of pneumogastric; 4, glosso-pharyngeal nerve; 5, lingual nerve; 6, spinal accessory; 7, middle constrictor of pharynx; 8, jugular (internal) vein (cut); 9, superior laryngeal nerve; 10, ganglion of trunk of pneumogastric; 11, hypoglossal nerve on hyoglossus; 12, ditto communicating with 8th and 1st cervical nerve; 13, external laryngeal nerve; 14, second cervical looping with the first; 15, pharyngeal plexus or inferior constrictor; 16, superior cervical ganglion of sympathetic; 17, superior cardiac nerve of pneumogastric; 18, third cervical nerve; 19, thyroid body; 20, fourth cervical nerve; 21, 21, left recurrent laryngeal nerve; 22, spinal accessory communicating with cervical nerves; 23, trachea; 24, middle cervical ganglion of sympathetic; 25, middle cardiac nerve of pneumogastric; 26, phrenic nerve (cut); 27, left carotid artery; 28, brachial plexus; 29, phrenic nerve (cut); 30, inferior cervical ganglion of sympathetic; 31, pulmonary plexus of pneumogastric; 32, thoracic aorta; 33, œsophageal plexus; 34, vena azygos superior; 35, vena azygos minor; 36, gangliated cord of sympathetic.

The *inferior maxillary nerve* closely resembles that of animals, the only differences consisting in: 1. The deep middle temporal nerve rising direct from the maxillary. 2. The lingual nerve is detached near the base of the cranium. 3. The superficial temporal nerve furnishes—independently of the filaments uniting it to the facial—an auriculo-temporal branch that ascends in front of the ear, and terminates in the skin of the temporal region.

In Man, there is annexed to the fifth pair the *submaxillary ganglion*, which receives a sensitive branch from the lingual, a motor filament from the chorda tympani, and sympathetic filaments; it gives off several emergent filaments, nearly all of which pass into the maxillary gland. There is nothing to say of the *internal motores oculorum.*

Facial.—In its collateral branches, the facial nerve of Man is absolutely the same as in animals. It has, however, a branch not described in them—the *ramuscule of Hirschfeld*, which reaches the base of the tongue, where it is distributed by mixing with the glosso-pharyngeal. The termination much resembles that of the Dog. Two principal branches have been named the *temporo-facial* and the *cervico-facial.* The first receives the superficial temporal nerve, and describes an arch from which are detached the temporal, frontal, palpebral, suborbital, and buccal ramuscules, which form the subparotideal plexus. The second, lodged in the parotid gland, passes towards the angle of the jaw, where it anastomoses with the cervical plexus; it furnishes the inferior buccal, mental, and cervical branches.

Glosso-pharyngeal.—This nerve commences and terminates as in Solipeds, and has the same relations. It furnishes the *branches of the digastric* and *stylo-hyoid muscles*, the filament of the *stylo-glossus muscle*, and, finally, the tonsilitic ramuscules that form, around the amygdala, the *tonsilar plexus.*

Pneumogastric.—Formed by the union of the sensitive roots, the pneumogastric leaves the cranial cavity by the posterior foramen lacerum; in the interior of that foramen it shows the jugular ganglion; a little lower, it has a second fusiform enlargement—the *gangliform plexus*—which is found in the Dog. Here it receives the internal branch of the spinal accessory, or otherwise its motor roots. Beyond this gangliform enlargement, the pneumogastric is placed a little within the sympathetic, descends along the neck, enters the chest, and terminates on the stomach and in the solar plexus. The relations of the two pneumogastrics in the thoracic cavity are the same as in animals. In terminating in the semilunar ganglion, the two pneumogastrics unite and form an arch named the *memorable loop of Wrisberg.*

The various anastomoses of the pneumogastric in Man offer nothing particular.

The *pharyngeal branches* leave the gangliform plexus, and are constituted by the filaments carried to the pneumogastric by the internal root of the spinal accessory. They are two, three, or four in number, and form the pharyngeal plexus.

The *superior laryngeal nerve* also arises from the gangliform plexus, and offers, as in Ruminants, a Galien branch that anastomoses, end to end, with a branch of the inferior laryngeal. The *external laryngeal* is furnished by this nerve; it is distributed to the inferior constrictor muscle of the pharynx, the crico-thyroid muscle, and the mucous membrane of the subglottic portion of the larynx and the ventricle of the glottis.

The *recurrent nerves* affect a distribution analogous to that already made known.

The pneumogastric also gives *cardiac*, *pulmonary*, and *œsophageal branches.* The cardiac lie beside those coming from the sympathetic and recurrents, and enter the ganglion of Wrisberg, situated at the base of the heart. The œsophageal branches are remarkable for their number and complexity, and form a veritable œsophageal plexus. The gastric branches are also very numerous.

Spinal accessory.—It presents bulbous roots which are well known, and medullary roots which usually extend to the fifth cervical, and sometimes to the first dorsal. After its exit from the posterior foramen lacerum, it divides into two branches—an internal and external. The internal branch, formed by the bulbous roots, enters the gangliform plexus of the pneumogastric. The external branch comports itself as in animals.

The *hypoglossal* resembles that of Carnivora, and, like it, possesses a branch for the hyo-thyroideus and genio-hyoideus.

CHAPTER II.

SPINAL NERVES.

We designate as *spinal, vertebral*, or *rachidian nerves*, those which emanate from the spinal cord, and leave the vertebral canal by the intervertebral foramina to proceed to the various organs.

They are estimated at 42 or 43 pairs, and are apportioned as follows in the five regions of the spine: *cervical*, 8 pairs; *dorsal*, 17 pairs; *lumbar*, 6 pairs; *sacral*, 5 pairs; and *coccygeal*, 6 to 7 pairs.

They differ from the cranial nerves in closely resembling each other in the fundamental points of their constitution. All proceed from the lateral aspects of the spinal cord by two orders of roots: one motor, the other sensitive. In all, these two roots unite into a very short trunk in passing through the intervertebral foramen; and this mixed nerve divides almost immediately into two terminal branches—a superior, destined to the spinal muscles and the teguments covering them; the other, inferior, passes to the lateral and lower parts of the trunk or to the limbs. All send, from their inferior branch, one or more ramuscules to form the great sympathetic.

The roots of the spinal nerves offer everywhere the same disposition; each nerve is formed by two fasciculi of converging filaments—superior and inferior—which are naturally more numerous and large when they belong to voluminous trunks, as may be remarked in those proceeding from the two bulbous enlargements of the spinal cord. The common axis of these two fasciculi affects a transverse direction in nearly all the spinal pairs; but that of the posterior nerves inclines more backwards, as they reach the terminal extremity of the cord.

The filaments of the superior fasciculi—or *sensitive roots*—are larger than the others, and emerge from the collateral groove on the spinal cord. They may be followed, in animals, to the cells of the superior grey cornua. But these cells are not sufficiently numerous to receive all the fibres of the superior roots, and some of these pass into the cells of Clarke's columns.

The filaments of the inferior fasciculi—or *motor roots*—arise opposite the preceding, on the lower face of the cord, at a short distance from the middle line, and on the limits of the inferior and lateral columns. They may also be traced to the interior of the cord, as far as the inferior grey cornua.

These filaments do not unite to form their common trunk until after they have passed through the dura mater. This is an extremely short trunk that occupies the corresponding intervertebral foramen, and presents on its upper face a ganglionic enlargement, which is exclusively placed on the course of its sensitive fibres; the motor filaments being simply laid beside them, and do not mix with them until beyond the ganglion. Immediately after this union, a small filament is given off that enters the spinal canal to be distributed to the sinuses and the bodies of the vertebræ.

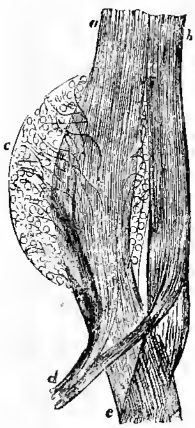
After leaving the meningeal sheath, the radicular fasciculi of the nerves, furnished by the terminal extremity of the spinal cord, run a somewhat long course in the sacral canal, before finally uniting and passing into the tissues. The common fasciculus they collectively form at the posterior extremity of the spinal canal is named the *cauda equina*.

The distributive branches of the spinal nerves cannot be considered in a general manner, because of their diversity. We will study them successively in each region of the spine.

Article I.—Cervical Nerves (8 Pairs).

Superior Branches.—The *first* (the *suboccipital* of Willis) passes through the superior foramen of the atlas, in company with the cerebro-spinal artery. It arrives in the space between the small oblique muscle of the head and the posterior straight muscles, and divides immediately into several divergent branches, which are distributed to the three above-named muscles, the anterior extremity of the complexus, and the cervico- and temporo-auricular muscles. The ramuscule sent to the latter ascends within the concha, and breaks up into several filaments that supply the skin of the external ear.

Fig. 464.



GANGLION OF A SPINAL NERVE FROM THE LUMBAR REGION OF A PUPPY.

a, Superior root; *b*, inferior root; *c*, ganglion on the superior root; *d*, *e*, junction of the fibres from the inferior and superior roots with those coming from the ganglion; *d*, superior trunk of spinal nerve; *e*, its inferior trunk.

The *second* immediately furnishes some ramuscules to the obliquus capitis posticus muscle, beneath which it is placed, as well as to the anterior oblique. It is afterwards directed backwards, comporting itself like the succeeding ones.

These diminish in volume from the third to the eighth. All pass through the intertransversales muscle, and divide into several branches, which are distributed to the muscles and integuments of the superior cervical region. Among these, the superficial, which are almost rudimentary in the two last pairs, reach the inner face of the splenius. The others, deep and more voluminous, cross the semi-spinalis colli, and, dividing, ascend between the complexus and cervical ligament, to near the superior border of that large elastic layer. They generally intercommunicate by several filaments, and in this way form a network on the inner face of the complexus, which Girard named the *deep cervical plexus*.

Inferior Branches.—These branches augment in size from the first to the last, and separate into two perfectly distinct groups. The divisions of the first six cover the lateral and anterior parts of the neck, as well as the muscles of the breast. Usually anastomosing with each other by long communicating branches, they in this way form a vast nervous network traversed by two important nerves—the spinal accessory and cervical filament of the facial; this is the *superficial cervical plexus*. The other two are united with the preceding by a filament passing between the sixth and seventh, soon becoming confounded with each other, as well as with the two first branches of the dorsal region; they constitute—in common with the latter—the *brachial plexus*.

Without saying any more as to the disposition of this double plexus, we will pass to the particular description of each cervical pair of nerves.

First.—Deeply situated beneath the transverse process of the atlas, this nerve leaves the anterior foramen of that vertebra, and accompanies the occipital artery and vein to place itself immediately between the rectus capitis anticus minor and rectus lateralis muscles. It then crosses the rectus capitis anticus major and the spinal accessory nerve, which it separates; and arrives, after describing a slight curve forward, near the thyroid gland, finally entering the subscapulo-hyoideus by several terminal divisions.

Near its origin, this inferior branch of the first cervical nerve furnishes collateral ramuscules to the three recti muscles of the head. Lower, it is in communication with the superior cervical ganglion and the spinal accessory nerve by several filaments. At the carotid artery, it sends forwards, to the side of the larynx, a very fine branch that quickly divides into two ramuscules, one of which joins the hypoglossal nerve, and the other goes to the thyro-hyoid muscle. It then throws off, from its convex side, several small descending nerves, all of which are destined to the subscapulo-hyoid, sterno-hyoid, and thyroid muscles.

One of these filaments, joined by a ramuscule from the second pair, is distinguished for its great length; it may be followed to near the sternum, where it is expended in the fleshy mass common to the four muscles that extend from that bone to the larynx and os hyoides. Its constant disposition should obtain for it the name of *pre-cervical nerve.*

Second.—This descends beneath the obliquus posticus, crossing the direction of the rectus anticus major, and ramifying therein by numerous branches. We specially indicate: 1. Those furnished to the latter muscle, and which are the shortest and deepest. 2. The *atloid loop*, a long, thick superficial branch, which enters the anterior portion of the levator humeri, and is directed forward and upward on the parotid gland, bending round the transverse process of the atlas; this ramuscule gives off filaments to the parotido-auricularis, as well as to the panniculus of the face, and terminates in two branches of unequal volume, the largest of which ascends on the outer side of the concha, and the other, situated behind, reaches the cervico-auricular muscles. 3. Another superficial branch, which passes over the jugular, near the junction of the glosso-facial, and divides into two ramuscules; these proceed forward with the submaxillary facial vein to the submaxillary space, where they are distributed to the skin and subcutaneous muscle. 4. Anastomosing filaments, which unite it to the two branches of the spinal nerve. 5. Accessory ramuscules to the cervical filament of the facial nerve. 6. Two communicating branches which pass beneath the rectus anticus major: one going to the first, the other to the third pair of nerves. 7. A deep branch going to join the pre-cervical filament of the first pair, and directly throwing off some fine divisions to the subscapulo-hyoideus muscle. 8. A last branch that arises at the intervertebral foramen, and passes at first—with the vertebral artery—into the posterior foramen of the second vertebra, and afterwards those of the succeeding vertebræ, to enter the inferior cervical ganglion of the sympathetic nerve, receiving on its course filaments from the third, fourth, fifth, sixth, and seventh pairs.

Third, fourth, fifth, and sixth.—Each of these crosses the intertransversales colli by a different interstice to that through which the corresponding superior branch passes. They gain the inner face of the mastoido-humeralis, where they divide into deep and superficial ramifications.

The first are distributed to the deep muscles of the sides, and anterior part of the neck and shoulders. Among them ought to be distinguished those which form a communication between the four pairs, and the third with the second. Very long and thin, these filaments lie on the side of the large muscular mass formed in front of the cervical vertebræ by the rectus anticus, longus colli, and scalenus muscles. There they form sometimes arches, and at other times anastomoses by convergence. Those of the fifth and sixth pairs, uniting at the anterior border of the scalenus with a branch of the brachial plexus, constitute the *diaphragmatic* (*phrenic*) *nerve*, which will be noticed hereafter.

The superficial ramuscules gain the external surface of the mastoido-humeralis by traversing its substance, or passing between its two portions. Much more numerous and larger than the preceding, they are distributed—in front—to the cervical panniculus; behind, to the trapezius; or below, to the mastoido-humeralis and pectoralis anticus and transversus. Those passing to the two last muscles are very long and voluminous; they represent the *acromial* and *clavicular* branches of the *cervical plexus* of Man. It may be remarked that the posterior filaments generally communicate with the spinal accessory, while the anterior ones, in meeting the cervical branch of the facial nerve on the jugular, often give it some anastomosing fibres.

Seventh.—An enormous branch comes from the interstice between the two portions of the scalenus, to pass entirely into the brachial plexus. It usually receives an anastomosing twig from the diaphragmatic filament furnished by the sixth pair.

Eighth.—This is thicker than the preceding, and comports itself like it. It directly furnishes its anastomotic branch to the inferior cervical ganglion.

Article II.—Dorsal Nerve (17 Pairs).

These nerves, numbering seventeen pairs, comport themselves in an extremely simple and almost identical manner; so that their description is not nearly so complicated as that of the nerves of the cervical region.

Superior Branches.—They present two principal ramuscules for the spinal muscles and the skin of the dorso-lumbar region. One ascends towards the summit of the spinous processes of the dorsal vertebræ, by passing between the semi-spinalis and longissimus dorsi; the other is directed outwards, in traversing the substance of the latter muscle.

Inferior Branches.—These are more considerable in size than the preceding, and descend into the intercostal spaces, between the pleura and the internal intercostal muscles, or even in the texture of these. With the exception of the first, the arrangement of which is different, they all pass at first over the head of the posterior rib to reach the convex border of the anterior one, and follow it to the extremity of the intercostal space.

There they terminate in the following manner: those of the sternal ribs traverse the pectoral muscles, giving filaments to these, and are expended in the skin of the subthoracic region. Those of the asternal ribs enter the abdominal muscles, passing between the transversalis and rectus abdominis; they also give cutaneous filaments to the skin of the abdomen.

Near their origin, the inferior branches communicate with the sympathetic, for the most part, by several filaments.

In their course they furnish numerous fine ramuscules to the intercostal muscles, and, in addition, give off—about the middle of their length—a very thick division—the *perforating intercostal branch*, which traverses the costal muscles and descends beneath the panniculus carnosus, ramifying partly in that muscle and partly in the skin. The most anterior perforating branches generally anastomose with the subcutaneous thoracic branch of the brachial plexus.

With regard to the first dorsal pair, its inferior branch enters the latter plexus; but it nevertheless furnishes an intercostal branch, always extremely slender, which passes over the external intercostal muscle to be expended in its substance, before arriving at the sternum. The second pair also concurs in the formation of the brachial plexus, though only by a small branch.

Article III.—Lumbar Nerves (6 Pairs).

Superior Branches.—Distributed to the spinal muscles and the integuments of the loins and croup, these are larger than the corresponding branches of the dorsal region, but present an analogous disposition. They give superior ramuscules to the muscles of the spine, and very long external divisions which pass through these muscles, to be distributed to the skin of the croup.

Inferior Branches.—The *first*—comprised in the interval separating the last rib from the first lumbar transverse process, between the quadratus lumborum and the psoas magnus—passes downwards and backwards until it arrives between the transverse and internal oblique muscles of the abdomen, to which it gives filaments, and is finally distributed in the rectus abdominis muscle.

Above the superior border of the internal oblique muscle, it furnishes a perforating branch to the skin of the flank and the posterior part of the panniculus carnosus.

The *second*, disposed in the same manner as the preceding, follows an analogous course, and breaks up into several divisions which are lost in the internal oblique muscle. From one of these sometimes emanates a slender filament, which joins one of the inguinal nerves of the third pair. We must not overlook, in the enumeration of the branches emitted by this second pair of lumbar nerves, the two perforating branches which descend in front, and on the inside, of the thigh, to be distributed to the skin of the flank and the internal crural region.

The *third*[1] also passes outwards, above the psoas muscles, which receive from it several divisions, and ramifies in the muscles of the flank. It has also perforating nerves, destined to the inguinal region, and these comport themselves in a sufficiently interesting manner to merit particular mention. They are usually three in number—an *internal* and two *external inguinal nerves.* The three pass at first beneath the peritoneum, and are directed backwards, downwards, and outwards, towards the inguinal canal, which they enter—one to the inside, the other to the outside of the spermatic cord. They give off some filaments to the cremaster and abdominal muscles, and at last ramify in the envelopes of the testicle, the sheath, and the skin of the inguinal region. The two external nerves are often confounded in a single trunk, on their arrival at the cremasteric muscle. The disposition they affect at their origin is extremely variable; sometimes they have each a distinct commencement, and separately traverse either the small or large psoas muscle, or the space between these; and, at other times, the internal and one of the external inguinal nerves proceed from a common trunk at the intervertebral foramen, the second external nerve then arising alone towards the external border of the psoas magnus muscle. Most frequently, the internal nerve receives a branch from the fourth pair, and it is even sometimes entirely formed by that branch. This variation in arrangement is not, however, the exclusive appanage of the inguinal nerves; we have seen the third pair alone furnish these three nerves and the filaments to the psoas muscles, without being prolonged into the muscles of the flank.

The *fourth*[2] pierces the psoas parvus muscle, and enters the space separating

[1] Representing the *abdomino-genital* and *femoro-genital* branches of Man.

[2] The *femoro-cutaneous branch of the lumbar plexus* of Man.

it from its congener—the psoas magnus. After passing between the peritoneum and the lumbo-iliac aponeurosis, it arrives below the angle of the haunch, and makes its exit from the abdomen ; it then descends within, and in front of, the tensor fascia lata muscle, and, accompanying the divisions of the circumflex iliac artery, it is prolonged to the stifle, where it is expended in the skin. At its origin, it gives : 1. A thick, short branch to the psoas magnus muscle. 2. A large anastomosing branch which concurs in the formation of the lumbo-sacral plexus. 3. A filament that joins the internal inguinal nerve furnished by the third pair. We have already mentioned that this nerve sometimes emanates entirely from the fourth pair.

The *fifth* and *sixth*—much more voluminous than the preceding—unite, and, with the three first sacral pairs, form the plexus of the abdominal limb.

All the inferior lumbar branches communicate with the sympathetic by several filaments, which pass across the fasciculi of the psoas parvus muscle ; and all communicate with each other—the two last by fusion of their fibres, and the first five by means of more or less voluminous anastomotic branches, which are far from being constant.

Article IV.—Sacral Nerves (5 Pairs).

We describe, as *sacral nerves*, not only the four double cords which escape by the lateral foramina of the os sacrum, but also the nerve that passes through the intervertebral foramen between that bone and the last lumbar vertebra.

Superior Branches.—These are small ramuscules that pass through the supra-sacral foramen, reach the muscles lodged on the sides of the sacral spine, and terminate in the skin of the croup.

Inferior Branches.—Thick nerves, which diminish in volume from the first to the fifth, and leave the sacral canal to pass downwards and backwards on the sides of the pelvic cavity.

The *first*, *second*, and *third* are directed towards the great sciatic opening, and are united into a wide nervous band that constitutes the pelvic portion of the lumbo-sacral plexus, to be described at another time.

The *fourth* and *fifth* course along the side of the pelvic cavity—in the texture of the sacro-sciatic ligament, or even within it ; united at their base by an anastomosing filament, they do not usually communicate—at least, in a direct manner—with the fasciculus formed by the three first pairs.

The *fourth* constitutes the *internal pudic* nerve, which passes between the two roots of the corpora cavernosa in bending round the ischial arch, where it lies nearly alongside its fellow of the opposite side. This nerve afterwards descends on the dorsal border of the penis, in the midst of the magnificent venous plexus of that organ, describing flexuosities which allow it to adapt itself to the elongation of the penis. Arriving at the extremity of the organ, it terminates in numerous divisions in the proper erectile tissue of this part, or in the mucous membrane covering it. On its course it emits very long flexuous branches, the ultimate ramifications of which enter the corpora cavernosa, or go to the urethral canal. Before leaving the pelvis, it gives off, behind, two thin ramuscules to the muscles and skin of the perineo-anal region. These ramuscules, like the principal trunk, receive anastomotic filaments from one of the ischio-muscular branches of the lumbo-sacral plexus.

The *fifth* is the *anal* or *hæmorrhoidal* nerve. It passes backward, above the preceding, and is distributed to the sphincter ani muscle and the surrounding integuments. Before quitting the pelvis, it gives a ramuscule to the levator ani.

The five inferior sacral branches emit, near their origin, a more or less slender filament that proceeds to the pelvic or hypograstic plexus. The anastomosing divisions, through which they communicate with the sympathetic chain, are generally thick, short, and multiple.

Article V.—Coccygeal Nerves (6 to 7 Pairs).

In the coccygeal region are found two pairs of nerves—one placed beneath the compressor muscle of the tail, the other below the curvator muscle. These two nerves extend to the extremity of the tail, throwing off on their track some muscular and cutaneous filaments. They are formed by the superior and inferior branches of the coccygeal nerves, which gradually amalgamate to form the two nerves.

These coccygeal branches are six or seven in number, and very distinct; they diminish in volume from the first to the last. The first only gives a slender filament for the formation of each coccygeal trunk; it is chiefly expended in the integuments and muscles at the base of the tail.

Article VI.—Composite Nerves formed by the Inferior Branches of the Spinal Nerves.

We already know that these nerves represent three groups: 1. The *diaphragmatic nerve*. 2. The *brachial plexus*. 3. The *lumbo-sacral plexus*. They will be studied in this order.

Diaphragmatic (or Phrenic) Nerve.

The *diaphragmatic nerve* (the *internal respiratory nerve* of Bell) is formed by two principal branches, and a small accessory ramuscule, the presence of which is not constant. The latter comes from the fifth cervical pair; the two others proceed, one from the next pair, the other from the brachial plexus. The branch from the sixth pair pierces the inferior scalenus muscle from within to without, gives off a filament to the brachial plexus, and descends obliquely backwards to the surface of the muscle it passes through, to unite—at the entrance to the chest—with the branch of that plexus. This latter branch, generally shorter and thicker, comes exclusively from the seventh cervical pair.

The trunk of the diaphragmatic nerve, formed in this manner, passes into the thorax after receiving the branch of the fifth pair—when it exists—passes within the axillary artery, along with the pneumogastric nerve, and often at this point—if not always—obtains a filament from the sympathetic. It then gains the side of the base of the heart, passing beneath the pleura, and finally attains the tendinous centre, after a course of at least eight inches between the two layers of the posterior mediastinum—the left nerve being in the mediastinum proper,[1] while that of the right side lies in the special serous partition for the posterior vena cava.

[1] Lesbre has found, in an Ass, an anomaly in the course of the left diaphragmatic nerve. It passed directly from the base of the heart to the anterior face of the diaphragm, being sustained in the middle of the corresponding portion of the pleural cavity by a special fold, analogous to that of the posterior vena cava in the right pleura.

Even before its arrival at the tendinous centre, this nerve divides into several branches, the ramifications of which pass to the sides of the crura of the diaphragm.

Brachial Plexus.

This plexus comprises an enormous fasciculus of nerves, situated between the thoracic parietes and the inner face of the anterior limb, formed by the inferior branches of the sixth, seventh, and eighth cervical, and the two first dorsal pairs; they are principally sent to the muscles and integuments of that limb.

Mode of constitution.—The sixth cervical pair only assists in the formation of this plexus, by the slender filament from its diaphragmatic branch; but the next two are entirely devoted to it, as well as the first dorsal, with the exception of a very thin ramuscule, which constitutes the first intercostal nerve. The root furnished by the second dorsal pair only represents a very small part of its inferior branch, the other portion forming a somewhat voluminous intercostal nerve.

The various branches converge towards each other, and gain the space between the two portions of the scalenus muscle (if we consider it as one), where they unite, and become confounded into a single fasciculus by sending filaments and ramuscules to each other; this fasciculus soon separates into a certain number of divisions, the disposition of which will be referred to presently. It will be remarked that the intercrossing of the branches composing the brachial plexus does not occur in a confused and irregular fashion, and if the reticulation of the ramuscules passing from one to another does not take place in a constant manner, it is, at any rate, far from being inextricable. It is easy to follow the filaments from any pair of nerves for a certain distance in the divisions given off by the brachial plexus, especially after maceration in dilute nitric acid. This originating fasciculus of the brachial plexus is very wide and short. It is at first comprised between the superior portion of the scalenus (or superior scalenus) and the longus colli. In its course between the two portions of that muscle, it bends round the first rib by its posterior border, and is related inwardly to the vertebral artery and vein, as well as to the vertebral nerve-filament proceeding to the sympathetic, and accompanying these vessels.

Mode of distribution.—Immediately after leaving the interspace in the scalenus, the brachial plexus arrives beneath the shoulder, near the scapulo-humeral angle. There it divides into a certain number of branches, amongst which it is impossible to distinguish the terminal divisions and collateral ramuscules. Without noticing this distinction, however, we will describe them in succession, commencing with those that pass to the trunk, and afterwards those which are destined for the limb. The latter will be examined in the following order: first, the shortest branches, or those which proceed to the upper parts of the member; and next, the longest branches, or those passing to the foot.

All these divisions are named and classified in the following enumeration:—

NAME.	ORIGIN.
A. BRANCHES TO THE BODY.	
1. Diaphragmatic (phrenic) branches.	5th, 6th, and 7th cervical pairs.
2. Levator anguli scapulæ and rhomboideus branch.	6th cervical pair.
3. Serratus magnus, or superior thoracic branch.	6th and 7th cervical pairs.
4. Pectoral or inferior thoracic branches.	6th and 7th cervical pairs.
5. Subcutaneous thoracic branch.	1st and 2nd dorsal pairs.
6. Latissimus dorsi branch.	8th cervical pair.
B. BRANCHES TO THE SHOULDER.	
7. Circumflex or axillary nerve.	8th cervical pair.
8. Teres major branches.	8th cervical pair.
9. Subscapular branches.	7th cervical pair.
10. Supra-scapular nerve.	6th and 7th cervical pairs.
C. BRANCHES TO THE ARM AND FORE-ARM.	
11. Anterior brachial or musculo-cutaneous nerve.	7th and 8th cervical pairs.
12. Musculo-spiral or radial nerve.	1st dorsal nerve.
D. BRANCHES TO THE FOREARM AND FOOT.	
13. Ulnar or cubito-cutaneous nerve.	1st and 2nd dorsal pairs.
14. Median or cubito-plantar nerve.	8th cervical, and 1st and 2nd dorsal pairs.

PREPARATION OF THE BRACHIAL PLEXUS.—The animal is placed in the first position, and slightly inclined to one side by allowing one of the anterior limbs to hang unrestrained. The pectoral muscles are then excised close to their insertion in the unfixed limb, and turned upwards, maintaining them in this position by the chain tentacula which are attached superiorly to a band that unites the extremities of the two suspensory diagonal bars. Care should be taken to separate the pectoralis magnus from the panniculis, in allowing the latter to fall on the table along with the limb. By tearing through the considerable mass of connective tissue surrounding the nerves of the brachial plexus, these soon appear, and may be isolated with the greatest facility. It is advisable, in this dissection, to preserve the arteries; and it is also of importance to leave the perforating intercostal branches intact, in order to observe the anastomoses of these with the subcutaneous thoracic division.

In this operation, the anterior limb is very much separated from the trunk, and the relations of the nerves are necessarily more or less changed; but it exhibits the whole of the plexus in the most perfect manner.

To trace the divisions of the principal nerves from this plexus, a limb entirely removed from the body is made use of, and, if possible, with the arteries injected. The nerves are then found in their natural relations, and can be more readily dissected. Figs. 465, 466 will guide the student in looking for these nerve-divisions.

1. DIAPHRAGMATIC BRANCHES.

See the description of the diaphragmatic nerve above.

2. THE LEVATOR ANGULI SCAPULÆ AND RHOMBOIDEAL BRANCH (Fig. 465, 7).

Entirely furnished by the sixth cervical pair, this branch is directed upwards to the surface of the levator anguli scapulæ. It soon divides into several filaments, which are wholly expended in the substance of that muscle, the serratus magnus, and the rhomboideus. The filament supplying the latter is slender and very long, and, to reach its destination, passes through the levator anguli scapulæ.

3. SERRATUS MAGNUS, OR SUPERIOR THORACIC BRANCH (Fig. 465, 8).

This very remarkable branch proceeds, by two principal portions, from the fasciculus common to all the divisions of the brachial plexus—one emanating from the sixth cervical pair; the other from the seventh, and always traversing the last fasciculus of the superior scalenus before joining the first. The single branch resulting from the union of these two roots is thin and very wide. It passes back to the surface of the serratus magnus, crossing the direction of its fibres, and is expended in its substance, sending regularly arranged ramifications upwards and downwards.

This is the respiratory nerve of Bell.

4. Pectoral, or Inferior Thoracic Branches.

Five principal are distinguished :—

1. One emanating from the sixth and seventh cervical pairs—particularly the former—and passing to the internal face of the anterior deep pectoral muscle, to ramify exclusively among its fibres, after dividing into two branches: an anterior, short and thick, and a posterior, long and slender (Fig. 465, 10).

2. A second branch, arising from the anterior brachial and cubito-plantar (or median) nerves, by two roots, which join in forming an arch beneath the axillary artery.

It passes between the anterior and posterior deep pectoral muscles, and terminates in the superficial one, after furnishing some ramuscules to the posterior deep pectoral by means of a long thin filament, which is carried back to the external surface of that muscle (Fig. 465, 11).

3. The other three, passing to the posterior deep pectoral muscle, generally come from the trunk that constitutes the subcutaneous thoracic branch. Comprised between the serratus magnus and posterior deep pectoral, they are directed downward and backward, and enter the latter muscle. One of them—longer and thicker than the other—follows the course of the spur vein.

5. Subcutaneous Thoracic Branch (Fig. 465, 9).

This is a very remarkable nerve, arising from the brachial plexus by a trunk common to it and the ulnar nerve. Placed at first to the inside of that nerve, it soon leaves it to pass backward to the internal face of the caput magnum and the panniculus carnosus. In its long course, it acts as a satellite to the spur vein, above which it is situated. It may be followed to the flank, where its terminal divisions are lost in the substance of the panniculus muscle. Those it gives off are also destined to that muscle; they anastomose with the majority of the perforating intercostal nerves, forming an elaborate network on the inner face of the panniculus.

One of its branches, along with a voluminous perforating nerve, bends round the inferior border of the latissimus dorsi, and passes forward to enter the scapulo-humeral portion of the panniculus.

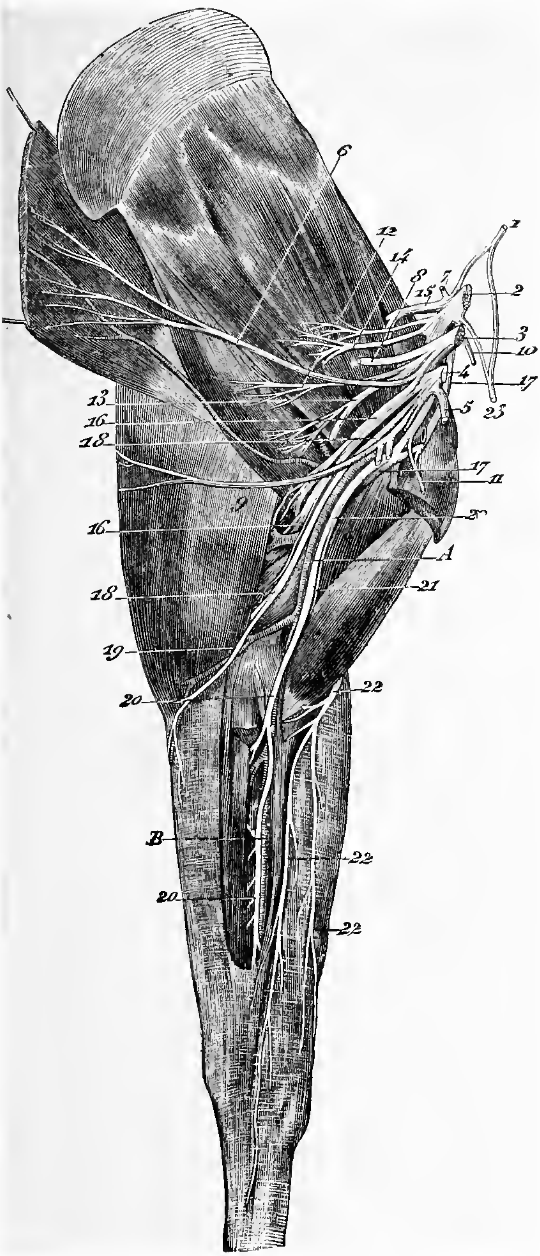
6. Latissimus Dorsi Branch (Fig. 465, 6).

Formed of fibres, the larger portion of which come from the eighth cervical pair, this branch proceeds backwards and upwards to the internal face of the latissimus dorsi, and is soon expended in that muscle. It is long and thick.

7. Circumflex or Axillary Nerve (Fig. 465, 13).

Somewhat considerable in volume, this nerve is furnished directly by the eighth cervical pair. It passes backward and downward on the internal face of

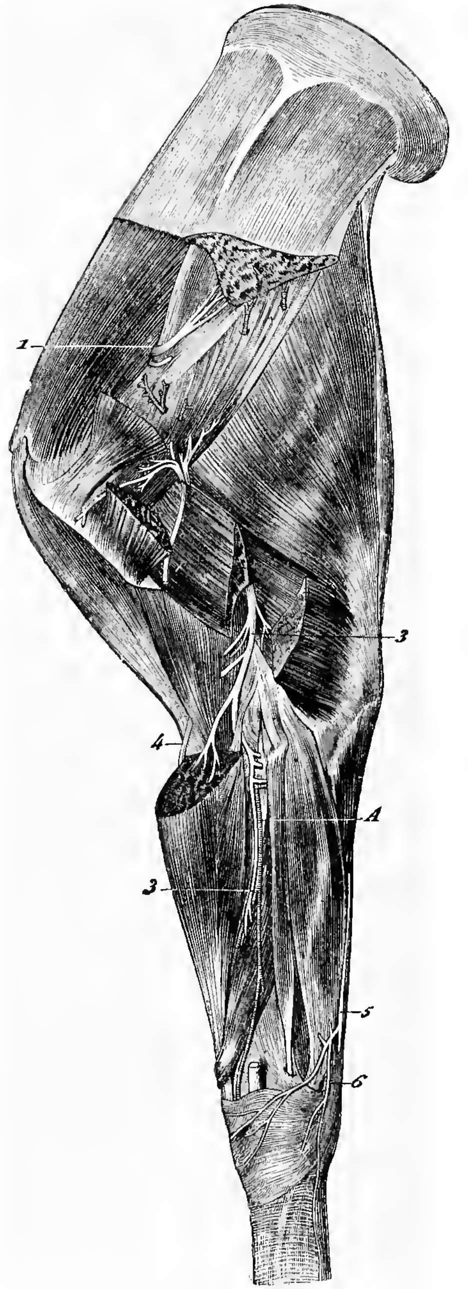
Fig. 465.



NERVES OF THE BRACHIAL PLEXUS.

1, Diaphragmatic branch of the sixth cervical pair, furnishing a branch to the brachial plexus; 2, seventh cervical pair; 3, eighth cervical pair; 4, first dorsal pair; 5, second dorsal pair; 6, great dorsal branch; 7, levator anguli scapulæ and rhomboideal branch; 8, superior thoracic branch; 9, subcutaneous thoracic branch, giving rise, near its origin, to the three inferior thoracic branches; 10, 11, two other inferior thoracic branches; 12, nerve of the teres major; 13, axillary nerve; 14, subscapular nerves; 15, supra-scapular nerve; 16, radial nerve; 17, anterior brachial nerve; 18, ulnar nerve; 19, its internal cutaneous branch; 20, median nerve; 21, its musculo-cutaneous branch; 22, 22, 22, superficial ramuscules of that branch. A, Humeral artery; B, posterior radial artery.

Fig. 466.



EXTERNAL NERVES OF THE ANTERIOR LIMB

1, Supra-scapular nerve; 2, axillary nerve; 3, radial nerve; 4, superficial ramuscule of the musculo-cutaneous nerve; 5, ulnar nerve; 6, its terminal cutaneous branch. A, Anterior radial artery.

the subscapularis muscle, to the interstice between it and the teres major, where it crosses the subscapular artery. It proceeds behind the scapulo-humeral articulation, along with the circumflex artery, enters between the teres minor and the caput magnum and medium, and, arriving beneath the deltoid, it divides into several diverging branches, destined to the teres minor, deltoid, mastoido-humeralis, and even to the integuments covering the anterior region of the arm.

Before entering the space that lodges the subscapular artery, it sends filaments to the scapulo-humeralis and gracilis muscle.

8. Nerve of the Teres Major (Fig. 465, 12).

This arises from the eighth cervical pair—like the preceding—by the one trunk, and passes backward, at first on the subscapularis muscle, then on the adductor, in the substance of which it disappears by numerous filaments.

9. Subscapular Branches (Fig. 465, 14).

These branches are two in number, and are generally derived from the trunk of the seventh pair. After a short course backwards, they divide into several ramuscules, which pass among the fibres of the subscapularis muscle.

10. Supra-scapular Nerve (Fig. 465, 15).

Very short and thick, this nerve is formed by the sixth and seventh cervical pairs. After a brief course backwards, between the levator anguli scapulæ on the one side, and the anterior deep pectoral, prescapularis, and supra-spinatus on the other, it gains the space between the latter muscle and the subscapularis, and enters it a little above the supra-scapular artery. It is then carried to the external face of the scapula, after bending round the anterior border of that bone, passes across the acromion spine, and ascends to the infra-spinous fossa, to expend itself in the muscle occupying this space. On its passage beneath the supra-spinatus muscle, it gives it several ramuscules.

11. Anterior Brachial or Musculo-cutaneous Nerve (Fig. 465, 17).

This nerve proceeds from the seventh and eighth cervical pairs, descends to the internal face of the scapulo-humeral articulation, and meets the axillary artery, which it crosses outwardly, at an acute angle. It then joins the median nerve by a large short branch, that passes beneath the artery and forms a loop around it; descending in front of the median nerve, to the bifurcation of the coraco-humeralis, it insinuates itself between the two branches of that muscle, and, breaking up into several ascending and descending ramuscules, enters the substance of the biceps. It also furnishes filaments to the coraco-humeralis, before its passage between the two branches of that muscle. Besides this, it concurs, by a small branch, in the formation of one of the anterior thoracic nerves.

12. Radial (or Musculo-spiral) Nerve (Figs. 465, 16; 466, 3).

This is certainly the largest nerve furnished by the brachial plexus. It arises chiefly from the first dorsal pair, and is directed backwards and downwards, on the inner face of the subscapularis and teres major muscles, crossing their direction. In this portion of its course, it proceeds parallel to the humeral artery, from which it is separated by the ulnar nerve. Arriving at the deep humeral artery—which it leaves on the outside—it passes behind the humerus with the divisions of that artery, and enters between the caput magnum and brachialis anticus. After creeping along the posterior border of the latter muscle, it gains the anterior face of the ulna-radial articulation, where it is covered by the two principal extensors of the metacarpus and the phalanges, and, meeting the radial artery, accompanies it on to the oblique extensor of the metacarpus. There it terminates by two branches, which enter the texture of that muscle.

In its course, it successively gives off—

1. Before leaving the internal face of the limb, to pass beneath the mass of extensor muscles of the forearm, a very thick fasciculus, composed of several branches—descending and ascending. The latter bend round the terminal tendon common to the latissimus dorsi and teres major, to become lost in the body of the great extensor; the others reach either the long and middle extensors, or the inferior portion of the principal muscle—the large extensor.

2. Behind the arm, filaments to the caput medium and anconeus, and several cutaneous ramuscules, disengaged from beneath the former muscle, that descend beneath the skin on the anterior face of that part.

3. In the antibrachial region, branches to the extensor metacarpi magnus and flexor metacarpi externus, and the two extensors of the digit.

In brief, we see that the radial nerve is distributed to, and therefore stimulates, the whole mass of the extensor muscles of the forearm and foot, besides a flexor of the latter; and that it endows the integument of the anterior antibrachial region with sensibility.

13. Ulnar or Cubito-cutaneous Nerve (Figs. 465, 18; 466, 5).

Chiefly formed by fibres from the dorsal pairs, this nerve—less considerable in volume than the preceding—passes backward and downward, and places itself behind the humeral artery, which it accompanies to below the origin of the deep humeral. After crossing the latter vessel, it passes between the scapulo-ulnaris and caput parvum, and gains the inner side of the elbow, running over the epicondyle, below the ulnar band of the oblique flexor of the metacarpus. It follows the posterior border of that muscle to near the pisiform bone, where it terminates by two branches. In the latter part of its course, it lies beneath the antibrachial aponeurosis, accompanied by a division of the epicondyloid artery.

One of the two branches—the *cutaneous* (Fig. 466, 6)—crosses the space between the terminal tendons of the external and oblique flexor muscles of the metacarpus, as well as the antibrachial aponeurosis, to expend itself in several ascending horizontal and descending filaments, beneath the skin of the forearm, the anterior face of the knee, and the external side of the cannon. The other branch, with a ramuscule from the median nerve, constitutes the *external plantar nerve*.

In its course, the ulnar nerve gives off two fasciculi of collateral branches. The first (Fig. 465, 19) is detached from the principal trunk a little above the epicondyloid artery, and passes backward and downward between the scapulo-ulnaris and the anterior superficial pectoral—supplying some filaments to the latter—traverses it to become subcutaneous, and to be distributed to the skin of the forearm, beneath the elbow (*internal brachial cutaneous*). The second arises at the epicondyle, and is destined to all the muscles of the posterior antibrachial region, except the external and internal flexors of the metacarpus.

14. Median or Cubito-plantar Nerve (Fig. 465, 20).

This nerve is composed of fibres coming from the dorsal and eighth cervical pairs. It is detached from the posterior part of the trunk of the plexus and proceeds towards the axillary artery, where it forms an anastomosis with the anterior brachial nerve, through the loop already noticed when describing that nerve as being formed by filaments passing from one cord to the other.

Leaving this point, it is placed in front of the humeral artery, and accompanies it to its terminal bifurcation; then it continues to descend on the inner face of the limb, along with the principal branch of that artery—the posterior radial—until it reaches the ulnar articulation, where it lies against the internal ligament of that joint, and crosses—at a very acute angle—the direction of its satellite vessel to become posterior. This position it inverts below the articulation, when it assumes, and preserves for the greatest part of its extent, its antibrachial course, remaining always a little more superficial than the artery. Above the lower third of the forearm, it bifurcates to form the *plantar nerves.*

In its course, this nerve successively furnishes—

1. Before its arrival on the axillary artery, one of the originating branches of the thoracic nerve passing to the anterior superficial pectoral muscle.

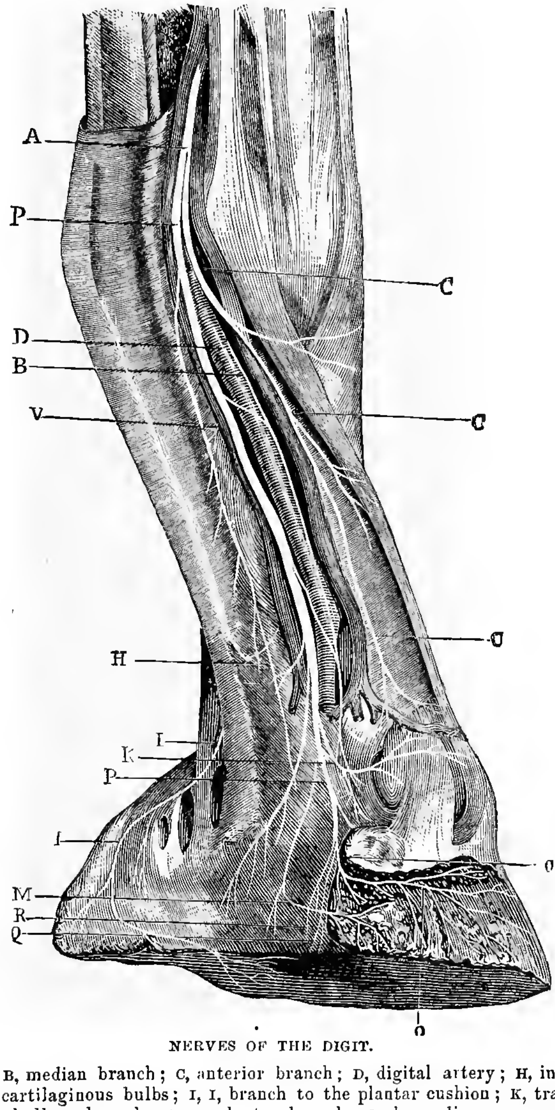
2. At the middle of the humerus, a long branch, represented in Man by that portion of the *musculo-cutaneous nerve* which proceeds to the anterior brachial muscle and the skin of the forearm. This branch enters beneath the biceps, and forms two divisions; one of these is expended in the brachialis anticus while the other passes between that muscle and its congener—the long flexor—to become superficial and gain the internal aspect of the limb, when it breaks up into two principal filaments, which pass to the external face of the antibrachial aponeurosis, and accompany with their divisions the two subcutaneous veins of the forearm to below the carpal region (Fig. 465, 21, 22).

3. In the antibrachial region, and at various elevations—but particularly below the ulnar articulation—ramifications to the internal flexor of the metacarpus and the two flexors of the phalanges.

Plantar Nerves.—These nerves, two in number, are distinguished as *internal* and *external.*

The *internal plantar nerve*—one of the terminal branches of the median nerve—lies beside the large metacarpal artery, and follows that vessel along the perforans tendon to near the fetlock, where it ends in several digital branches. In its track it furnishes a number of cutaneous metacarpal ramuscules, and an anastomosing branch, which, after being detached from the principal trunk, about the middle of the cannon, bends obliquely behind the flexor tendons to join the *external plantar nerve.* This is formed by the union of two branches—one coming from the ulnar nerve, the other from the median, and joining the first at the upper border of the pisiform bone, after passing beneath the inferior extremity of the oblique flexor of the metacarpus. This nerve, which accompanies the external metacarpal vein for its entire length, descends with it, and with an arteriole that concurs in forming the subcarpal arch, outside the flexor tendons, in a special fibrous channel of the carpal sheath. Near the superior extremity of the cannon, within the head of the external metacarpal bone, it sends on the posterior face of the suspensory ligament of the fetlock a *deep plantar* branch, chiefly destined to the fleshy portion of the interosseous muscles. It is the analogue of the *deep palmar branch* of the ulnar nerve in Man. Continuing its descending course along the perforans tendon, it throws off some superficial metacarpal ramuscules, receives the accessory branch supplied by the internal nerve, and terminates, like the latter, in a number of digital branches on arriving at the fetlock ; these it now remains for us to examine.

Fig. 467.



NERVES OF THE DIGIT.

P, Plantar nerve ; B, median branch ; C, anterior branch ; D, digital artery ; H, inconstant division given off to the cartilaginous bulbs ; I, I, branch to the plantar cushion ; K, transverse coronary branch ; M, podophyllous branch ; O, preplantar branch ; Q, descending ramuscule to the fissure of the patilobes ; R, ramuscules accompanying the digital artery in the plantar fissure ; V, vein which is not constant, and which sometimes accompanies the plantar nerve throughout its phalangeal course.

The *digital* branches are the terminal branches of the plantar nerves ; they are three in number on each side, and accompany the digital artery and vein, which, at some points, they cover with their divisions. They separate from one another nearly at the insertion of the suspensory ligament into the sesamoid bones. One of them descends in front of the vein; another passes between the two vessels; while the third follows the artery behind. They may, therefore, be distinguished, according to their position, into *anterior*, *middle*, and *posterior* (Fig. 467, M, O, R).

The *anterior branch* distributes its collateral divisions to the skin on the anterior face of the digit, and its terminal ramuscules in the coronary cushion.

The *middle branch* frequently anastomoses with the other two, particularly with the anterior, and to such a degree as to be scarcely distinguished from it; it enters the coronary cushion and the podophyllous tissue.

The *posterior branch*—much more considerable than the preceding, and a real continuation of the plantar nerve—is at first superposed on the digital artery, then it is placed immediately behind that vessel. It descends with it to near the basilar process of the third phalanx, follows the preplantar ungual artery into the lateral fissure of that phalanx, and, like that vessel, expends itself in the midst of the podophyllous tissue, as well as in the osseous structure. This branch gives off numerous ramuscules on its course. Of these there may be more particularly noticed: 1. Some posterior divisions, distributed behind the flexor tendons, especially at the fetlock. 2. A satellite branch to the artery of the plantar cushion. 3. A filament arising below the lateral cartilage, passing forward, in proximity to the anterior branch of the arterial coronary circle, and becoming lost in the meshes of the deep venous network of the cartilage. 4. A small podophyllous division, the origin of which is placed at the same height as the preceding filament, but opposite it, and which descends on the retrossal process, where it traverses the cartilaginous tissue to pass to the podophyllous reticulation, after distributing posterior ramuscules to the plantar cushion. 5. Several extremely fine filaments enlaced around the plantar ungual artery, and with it passing to the interior of the os pedis; some of these filaments ascend to the nerve of the opposite side.[1]

Differential Characters in the Brachial Plexus of the other Animals.

In the domesticated Mammals, the nerves of the brachial plexus do not offer any very important differences in the upper part of the limb; these only become apparent in the nerves of the last section.

Ruminants.—The branches of the plexus—the same in number as in the Horse—are relatively more voluminous than in that animal. In the **Ox** they are often flexuous in their upper part. In the **Sheep**, the *diaphragmatic nerve* is formed by a single filament, detached from the branch the sixth cervical nerve gives to the brachial plexus, and which passes over the surface of the scalenus; and a second branch which comes from the fifth pair, runs beneath the scalenus, and joins the first on the inner surface of the first rib (Toussaint). There are no

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[1] It is because we conform to established usages, and are unwilling to force analogies, that we preserve the designations of "plantar nerves" and "digital branches," as well as the above manner of describing them. Comparative anatomy desires other names and a different description; for it demonstrates that the external plantar nerve corresponds to the interosseous palmar of the second space in pentadactylous animals; and the internal plantar to the interosseous palmar of the third space. It also shows that the digital branches are the exact representatives of the collaterals of the digits which result, in the pentadactylous species, from a bifurcation of each interosseous nerve.

According to this description, it will be seen that the terminal branches of the median nerve are not only distributed over the posterior face of the digit, but that a good number of filaments are sent to the dorsal face—a remark which has been made in recent years, with reference to the distribution of the collateral palmar nerves of the human fingers.

differences in the *branch of the angularis and rhomboideus*, in the *branches of the pectoral muscles*, the *subcutaneous thoracic branch*, or the *anterior brachial* or *musculo-cutaneous nerve*.

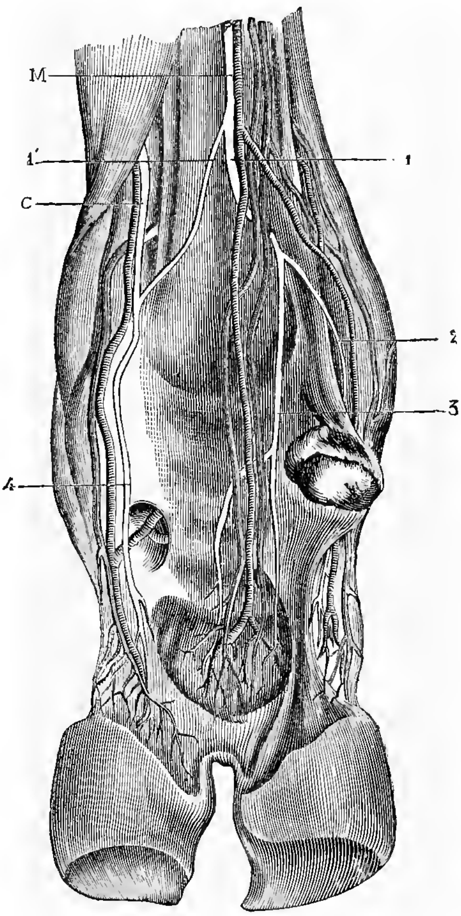
The *nerve of the serratus magnus* does not show the branch which, in the Horse, arises from the sixth nerve and passes through the scalenus; but on the surface of the serratus magnus it receives a filament from the branch of the angularis. The latter is detached from the sixth.

The branch of the *latissimus dorsi muscle* and the *axillary nerve* are confounded at their origin, and also adhere to one of the two branches of the *subscapularis nerve*. The second branch of the latter is free throughout its extent, and distributed in the muscle of the same name, along with some filaments furnished by the *supra-scapularis*.

The *radial nerve*, when it reaches the teres major, divides into three branches: one is buried in the long extensor of the forearm; the other traverses the middle extensor; and the third is inflected on the tendon of the latissimus dorsi, and passes between the middle and large extensor of the forearm. When the radial nerve turns outwards around the arm, and is placed between the anterior brachial and the mass of the olecranian muscles, it furnishes: 1. Muscular branches that pass immediately beneath the extensors of the metacarpus and phalanges. 2. A sensitive branch that leaves this muscular interstice to become subcutaneous. This cutaneous branch of the radial nerve gains the inner face of the forearm, and divides in two branches that descend parallel to the median subcutaneous vein. One of these is distributed around the carpus; the other is placed a little in front of the metacarpus, and reaches the metacarpo-phalangeal articulation, where it terminates by two principal filaments that constitute the *dorsal collaterals of the digits;* there is a third which crosses the interdigital to anastomose with the palmar collaterals.

The *ulnar* and *median nerve* of Ruminants lie beside each other, as far as the middle of the arm. This double cord is situated at the surface of the humeral artery; at the carpus the two nerves offer the same distribution as in the Horse, but beyond this there are some differences.

Fig. 468.



NERVES OF THE DIGITAL REGION OF RUMINANTS (POSTERIOR FACE).

M, Internal plantar nerve, a continuation of the median; C, internal plantar nerve, a continuation of the ulnar. 1, Branch of the plantar, furnishing, 2, the internal collateral nerve of the internal digit; 3, branch giving off the internal collaterals of the digits; 1′, branch of the internal plantar that joins the external plantar; 4, external collateral of the external digit.

The *ulnar* does not receive a branch from the median at the carpus, and it forms the *external plantar nerve* or interosseous palmar of the second space, placed at the external border of the flexor tendons. This nerve is reinforced by a filament detached from the external plantar, that joins it a little above the fetlock-joint; it gives ramuscules to the ergot, and is then continued by the external collateral nerve of the outer digit, into the toe.

The *median* is continued by the *internal plantar*, or interosseous palmar of the third space. Towards the inferior third of the metacarpus, it divides into three branches: the third passes to the external plantar; the second proceeds to the interdigital space, where it bifurcates to form the *internal collateral palmar nerves of the external digit*, and *external collateral of the* *internal digit;* the third gives some filaments to the ergot, and passes along the digital region, where it constitutes the *internal collateral of the internal digit.*

Pig.—Three fasciculi are detached from the brachial plexus; the posterior is the most voluminous, and furnishes the radial, median, and ulnar.

The branches of the plexus that pass to the trunk and the first segments of the anterior limb much resemble those of Ruminants; the *branch of the serratas magnus* is remarkable for its length and size.

The *median nerve* is disposed like that of Solipeds and Ruminants, as far as the carpus; from this point it passes beneath the flexor tendons of the phalanges, gives filaments to the interosseous palmar muscles, and at the two rudimentary digits divides into four branches: the two upper are the smallest, and forms the collaterals of the rudimentary digits; the inferior two are the longest, and reach the principal interdigital space, forming the collaterals of the two great digits.

The *ulnar* gives off, towards the middle of the arm, a branch that passes to the ulna; at the ulnar it furnishes several muscular branches. The nerve then bend round to the outside of the forearm, and on arriving above the pisiform bone, bifurcates: one branch goes along the outer border of the flexor tendons, and is continued by the collateral of the external digit; the other is placed on the anterior face of the metacarpus, and also bifurcates to give the external digits their dorsal collateral nerves.

Carnivora.—The four last cervical and first dorsal compose the brachial plexus in the Carnivora; the fifth cervical gives an insignificant filament. When the plexus is unravelled, its principal branches are observed to send fibres to each other.

The number of the distributive branches is the same as in Solipeds, and the disposition of the superior branches is so analogous as to call for no remark; so we will only describe the anterior brachial, radial, median, and cubital nerve.

The *anterior brachial,* or *musculo-cutaneous,* is constituted by a filament from the sixth cervical and the more voluminous branches coming from the seventh. Placed in front of the axillary artery, this cord arrives at the scapulo-humeral articulation, where it bifurcates: one of the branches passes forward to the biceps; the other remains alongside the anterior border of the humeral artery, and terminates by a slightly recurrent branch that is buried in the anterior brachial muscle, and by a very fine filament that becomes subcutaneous at the elbow, and descends on the inner border of the forearm to be lost in the vicinity of the carpus. The anterior brachial is, therefore, in these animals, a musculo-cutaneous nerve. The branch uniting it to the median nerve is situated a little below the middle of the humerus, instead of being beneath the axillary artery, as in Solipeds.

The *radial nerve,* in the **Dog,** is exclusively formed by the eighth cervical; it receives filaments from the median, ulnar, and axillary nerve, and gives branches to these three. When it reaches the interstice of the triceps and anterior brachial, it crosses the limb above the outer face of the elbow, and divides into two series of terminal branches.

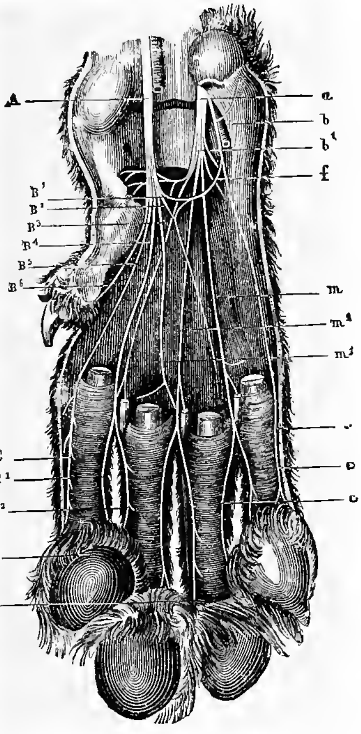
The muscular branch enters beneath the muscles on the anterior face of the forearm. The cutaneous bifurcates immediately: the smallest branch, passing inwards, extends beyond the bend of the elbow, lies at the inner border of the median subcutaneous vein, and is distributed to the lower moiety of the forearm, the thumb, and internal border of the index digit. The largest lies at the outer side of the median subcutaneous vein; it sends a recurrent ramuscule to the bend of the elbow, and, at the elbow, detaches three filaments to the first, second, and third dorsal intermetacarpal spaces; these filaments bifurcate at the dorsum of the digits to constitute the *collateral dorsal nerves.* The first metacarpal nerve anastomoses, by a fin transverse branch, with the ulnar ramuscule that constitutes the external dorsal collateral of the small digit.

To resume: the radial of the Dog gives branches to the dorsal face of all the digits, except the external border of first digit, or auricularis.

In the **Cat,** there are some differences. The internal branch of the *radial* sometimes lies with the external branch; it is placed at the inner border of the metacarpus, gives off a filament to the dorsal face of the thumb, and afterwards forms the internal dorsal collateral nerve of the index. The external branch leaves the anterior face of the carpus, and is situated at the origin of the third interosseous space, where it divides into three metacarpal branches; the external of these is very fine, and directed obliquely outwards, anastomosing with the dorsal branch of the ulnar, between the first and second digits.

The *median* of the **Dog** is united to the ulnar as far as the lower fourth of the arm; it is situated behind the humeral artery, and the filament it receives from the musculo-cutaneous joins it at a short distance from the elbow-joint. Placed beside the radial artery, the median is, towards the lower third of the forearm, immediately below the posterior border of the great palmar tendon; it afterwards passes through the carpal sheath, giving a branch that constitutes the *internal palmar collaterals of the thumb*, and *external of the index*; it finally forms three branches, the first of which anastomoses with the ulnar, at the surface of the palmar arch, and is lost on an artery; the other two, receiving a filament from the ulnar at the origin of the digits, bifurcate to form the *internal palmar collateral of the annularis*, and *collaterals of the medius and index*. The second gives, in addition, a slender branch, that is lost in the

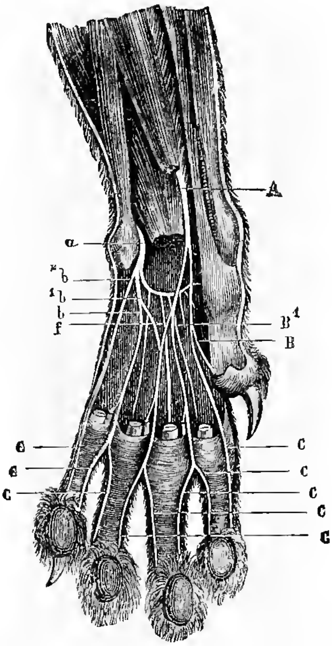
Fig. 469.



NERVES OF THE PALMAR FACE (DOG).

A, Trunk of the median dividing into six branches; B1, branch of the superficial nervous arch; B2, branch disappearing on a vessel; B3, B4, branches uniting with the corresponding ramuscules of the ulnar; B5, branch forming the internal collateral of the index; B6, rudimentary branch passing to the thumb; C, collateral given off by the median; C1, C2, C3, C4, collaterals furnished by the median and ulnar. *a*, Palmar branch of the ulnar; *b*, superficial branch giving off a filament to the hypothenar, and a second that forms the superficial nervous arch; *b*1, deep branch passing to the muscles of the skin; *m*, not anastomosing with the median; *m*1, *m*2, anastomosing with the corresponding branch of the median; the inoermost passes to the muscles of the thumb; *c*, *c*, *c*, collaterals furnished by the ulnar.

Fig. 470.



NERVES OF THE PALMAR FACE (CAT).

A, Trunk of the median dividing into two branches; B, internal branch, giving a rudimentary filament to the thumb, B1, external branch, receiving a filament, *f*, from the ulnar; C, C, C, C, collaterals furnished by the median. *a*, Palmar branch of the ulnar dividing into three branches; *b*, internal branch, detaching the filament, *f*, to the median; *b*1, external branch; *b*2, deep branch; *c*, *c*, *c*, collaterals furnished by the ulnar.

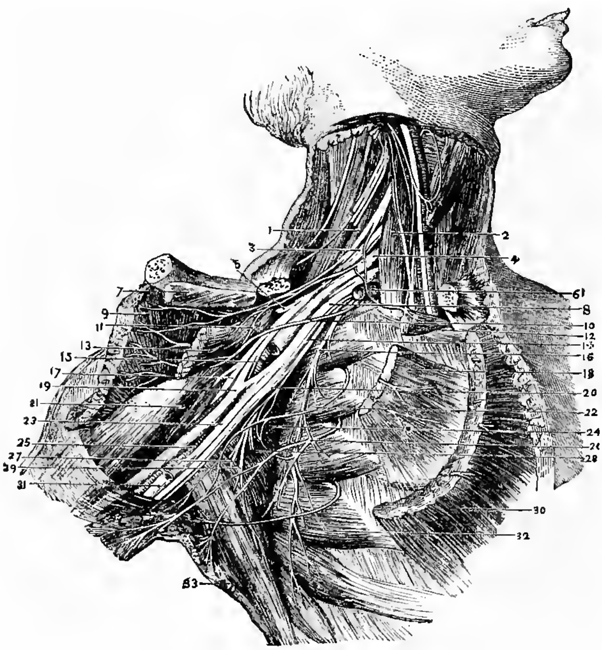
internal and middle lobe of the large cushion of the paw. In fine, the median of the Dog furnishes to all the digits, except the auricularis and external border of the annularis.

In the **Cat**, the median traverses the bony canal at the lower extremity of the humerus, and separates below the carpal arch into three branches. The internal branch is destined to the rudimentary thumb, and the internal palmar border of the index. The middle branch descends in the third interosseous space, furnishes a filament to the large cushion of the paw, and divides to form the external palmar collaterals of the index and internal of the medius. Finally, the exterual branch is placed in the second intermetacarpal space, and gives the following *palmar collaterals:* the *external of the medius* and *internal of the annularis.*

The *ulnar nerve* of the **Dog**, below the elbow, lies beside the ulnar artery to the lower third of that vessel; there it forms two branches—a dorsal and palmar. The *dorsal branch* becomes subcutaneous, passes along the external border of the forearm, metacarpus, and small digit, and constitutes the external dorsal collateral nerve of the latter.

The *palmar branch* leaves the carpal sheath, gives off, at the trapezoides, a ramuscule that passes to the surface of the palmar muscles to form the external collateral palmar of the auricularis, and then, at the surface of the deep palmar arch, divides into eight terminal

Fig. 471.



THE NERVES OF THE AXILLA OF MAN.

1, Scalenus medius; 2, scalenus anticus; 3, cord formed by 5th and 6th cervical nerves; 4, 7th cervical nerve; 5, superscapular nerve; 6, subclavian artery (cut), 7, insertion of subclavius; 8, cord formed by 8th cervical and 1st dorsal nerves; 9, pectoralis major (reflected); 10, internal anterior thoracic nerve; 12, origin of subclavius; 13, pectoralis minor (reflected); 14, internal cutaneous nerve; 15, axillary artery (cut); 16, posterior thoracic nerve; 17, musculo-cutaneous nerve; 18, origin of pectoralis minor; 19, median nerve; 20, nerve of Wrisberg; 21, coraco-brachialis; 22, intercosto-humeral nerve; 23, ulnar nerve; 24, subscapularis; 25, brachial artery; 26, lateral cutaneous branch of 3rd intercostal nerve; 27, middle subscapular nerve; 28, short subscapular nerve; 29, pectoralis major (cut); 31, basilic vein; 32, serratus magnus; 33, latissimus dorsi.

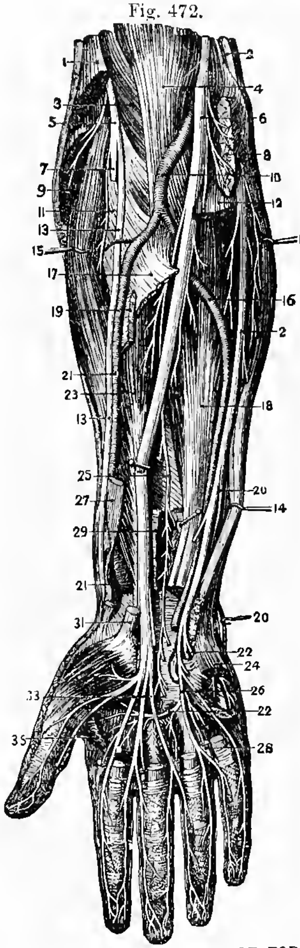
ramuscules. The smallest of these is expended in the rudimentary muscles of the thumb, the small digit, and interosseous muscles; the largest, three in number, lie on the interosseous arteries, and bifurcate at the digits to form the palmar collaterals; the two internal ramuscules are previously confounded with the corresponding branches of the median. From this arrangement, it results that the ulnar nerve supplies the palmar surface of all the digits, except the internal border of the index.

The *ulnar* of the **Cat** also divides into a dorsal and a palmar branch, but the distribution of these is not the same as in the Dog.

The *dorsal branch* bifurcates at the carpus: one of the filaments forms the external dorsal collateral of the small digit; the other reaches the first interosseous space, receives a branch from the radial, and afterwards gives off the internal dorsal collateral of the small digit, and external of the auricularis.

The *palmar branch* does not extend to all the digits as in the Dog. Passing within the pisiform bone, it divides into several filaments; some of these are distributed to the muscles of the small digit and thumb; another follows the external border of the small digit, and constitutes its external palmar collateral; one of the longest is lodged in the first intermetacarpal space, giving a filament to the large cushion of the paw, and the internal palmar collaterals of the small digit and external of the annularis.

Fig. 472.



NERVES OF THE FRONT OF FORE-ARM AND HAND OF MAN.

1, Supinator longus (cut); 2, ulnar nerve; 3, brachialis anticus; 4, biceps; 5, musculo-spiral nerve; 6, median nerve; 7, posterior interosseous nerve; 8, pronator teres and flexor carpi radialis (cut); 9, extensor carpi radialis longior (cut); 10, brachial artery; 11, supinator brevis; 12, flexor sublimis digitorum (cut); 13, 13, radial nerve; 14, 14, flexor carpi ulnaris; 15, extensor carpi radialis brevior; 16, ulnar artery; 17, radial origin of flexor sublimis digitorum (cut); 18, flexor profundus digitorum; 19, tendon of pronator teres; 20, 20, dorsal branch of ulnar nerve; 21, 21, radial artery; 22, 22, deep branch of ulnar nerve; 23, flexor longus pollicis; 24, abductor minimi digiti; 25, anterior interosseous nerve; 26, digital branches of ulnar nerve; 27, tendon of supinator longus; 28, one of the lumbricales muscles; 29, pronator quadratus; 31, tendon of flexor carpi radialis; 33, digital branches of median nerve; 35, adductor pollicis.

Comparison of the Brachial Plexus in Man with that of Animals.

The brachial plexus of Man, like that of the Dog, is constituted by the anterior branches of the four last cervical, and the last dorsal nerves. The few variations observed are very slight, and are to be ascribed to the difference in form of the regions to which the nerves are distributed.

The shoulder of Man being short, and the other segments of the limb long and well detached, the branches of the brachial plexus can be divided into collateral and terminal.

The *collateral* branches are: 1. The *subclavian branch*, which is not found in our animals, they having no subclavian muscle. 2. The nerve of the *levator anguli scapulæ*. 3. Nerve of the *rhomboideus*. 4. *Supra-scapular nerve*. 5. The *serratus magnus* (*posterior thoracic*) nerve. 6. *Subscapular*, which is divided at its origin into two branches as in the Sheep and Carnivora. 7. The nerves of the *great and small pectorals* (*anterior thoracic*). The *accessory nerve of the internal cutaneous*, represented in quadrupeds by the subcutaneous thoracic. 9. The nerve of the *latissimus dorsi*. 10. The *nerve of the teres major*.

The *terminal branches* go to the arm, forearm, and hand. They are:

1. The *internal cutaneous*, which in the Horse is furnished by the ulnar nerve. It becomes subcutaneous at the upper third of the arm, and a little above the elbow bifurcates; the anterior is spread on the anterior aspect of the arm to the wrist; the posterior passes backwards, and is expended in the skin of the back, and inner part of the forearm.

2. The *musculo-cutaneous*, or *perforans Casserii*, the disposition of which is analogous to that of Carnivora.

3. The *axillary nerve*, regarding which there is nothing to say.

4. The *radial nerve* (*musculo-spiral*) passes as in animals, lies in the musculo-spiral groove of the humerus, gives off an internal and external cutaneous branch, and reaches the antero-external part of the arm, in the space between the anterior brachial and long supinator, where

it terminates by two branches. The *anterior* of these reaches the back of the hand, and gives off three ramuscules there, which are distributed as follows: the first forms the external dorsal collateral of the thumb; the second bifurcates, and constitutes the internal dorsal collateral of the thumb and external collateral of the index; lastly, the third supplies the internal collateral of the index and external of the medius. This branch always anastomoses with the dorsal branch of the ulnar. The *posterior branch*—motor—is expended in the muscles on the posterior and external aspect of the forearm.

5. The *median nerve* commences by two branches. One arises in common with the musculo-cutaneous or anterior brachial, and corresponds to the anastomosis found around the axillary artery of the Horse; the other is detached from the trunk common to the ulnar and internal cutaneous. The median runs along the biceps, passes in front of the elbow, and lies beneath the annular ligament of the carpus, where it terminates in furnishing: 1. A filament to the short abductor of the thumb. 2. Palmar ramuscules to the thumb, index, and medius, and external border of the annularis. This disposition of the medius, therefore, much resembles that of the Cat.

6. The *ulnar nerve* passes along the inner border of the arm and forearm, and divides, a little above the inferior extremity of the olecranon, into two terminal branches—a *dorsal* and *palmar*. The first is directed on the back of the hand, and separates into three metacarpal branches, which, in their course, furnish the dorsal collaterals of the auricularis and annularis, and internal collateral of the medius; the other parts of the hand are supplied by the radial. The second, or palmar branch, is superficial, and detaches the palmar collaterals of the little finger and internal collateral of the annularis, as well as a deep ramuscule that lies across the interosseous muscles, and is a motor nerve. To resume, we see that this distribution of the terminal branches of the brachial plexus of Man much resembles that described in Carnivora, and especially in the Cat.

Lumbo-sacral Plexus.

The last two lumbar pairs, and the three first sacral, in becoming fused together, form the *lumbo-sacral plexus*, which corresponds in every respect—by its constitution, as well as by its mode of distribution—to the plexus of the thoracic limb.

It is usual, in human anatomy, to describe a *lumbar* and a *sacral plexus*, each formed by the inferior branches of all the spinal pairs, the names of which they bear. In our opinion, this course has two inconveniences. At first, it apportions into two fasciculi the nerves of the abdominal limb, and, besides in including in the description of these nerves the first lumbar pair and the last sacral, elements are introduced in this description which are altogether foreign to it. It may be remarked, that the four first lumbar pairs, when they anastomose with each other, do so by very slender filaments; that they only send some subcutaneous filaments to the posterior limb; that the two last sacral branches—principally for the genito-urinary organs and the posterior extremity of the digestive tube—are usually without any direct communication with the others; that the two last lumbar pairs and the three first sacral *are alone fused in the same manner as the brachial plexus, and comport themselves like that plexus in the distribution of their branches.*

It is with some reason, then, that we have described, in a special manner, the inferior branches of the four lumbar pairs and the two last sacral, reserving the fasciculus formed by the five intermediate pairs for a special description, under the name of the *lumbo-sacral plexus.*

Mode of constitution.—In glancing at this plexus, we may perceive that it is divided into two portions—an interior and posterior, each having a thick trunk in the centre.

The first of these trunks is formed by the two above-named lumbar pairs, which join each other after a short course, and after receiving an accessory branch from the fourth pair. The second—wider and thinner than the preceding—comprises the fibres of the three sacral pairs which escape from beneath the subsacral vessels, and unite in a single fasciculus. These two trunks are connected with each other by one or two branches proceeding from the first sacral pair to the obturator nerve—one of the distributive branches of the first.

Relations.—The *anterior portion* of the lumbo-sacral plexus is concealed beneath the psoas parvus muscle, and separated by the internal iliac artery from the *posterior portion.* The latter, placed above and on the side of the pelvis, at the sacro-sciatic foramen, corresponds, inwardly, to the subsacral vessels; outwardly, and in front, to the gluteal vessels.

Mode of distribution.—The anterior portion of the plexus at first gives off several small branches to the psoas muscles, and particularly to the iliacus—these branches were designated by Girard the *iliaco-muscular nerves;* it then terminates in two large branches—the *crural* and *obturator nerves.* The *posterior portion* is continued by two important trunks—the *great* and *small femoro-popliteal nerves.* At the base of the latter, it emits the *anterior* and *posterior gluteal nerves.* These branches and their ramifications will be successively studied.

Preparation of the lumbo-sacral plexus.—After removing the skin and abdominal viscera, the hind quarters are isolated by sawing through the vertebral column behind the last rib; then, by means of a section almost in the middle of the pelvis, one of the limbs is cut off, and the pieces, disposed as in Fig. 473, should be maintained in the first position—that is, with the croup resting on the dissecting-table near one of the bars, and the limb suspended vertically, the foot upwards, by a cord attached to the ring of the bar.

Afterwards, the preparation is executed in two stages. In the first, after the excision of the pelvic organs and the psoas parvus muscle, the whole of the plexus and its formative branches are dissected, taking Fig. 473 as a guide. In the second, the posterior part of the plexus, with the nerves it gives off, are exposed on the external side, by excising the greater portion of the principal gluteal muscle and the anterior portion of the biceps femoris, as in Fig. 474.

To follow the various divisions of the nerves emanating from the plexus, to their terminations, it is well to use the other limb, which, not being fixed, can be laid on a table, and in this way is more convenient than the first for this part of the operation.

A. Anterior Portion.

1. Iliaco-muscular Nerves.

These nerves are of little importance. The principal one accompanies the iliaco-muscular artery across the iliacus muscle.

2. Crural or Anterior Femoral Nerve (Fig. 473, 2).

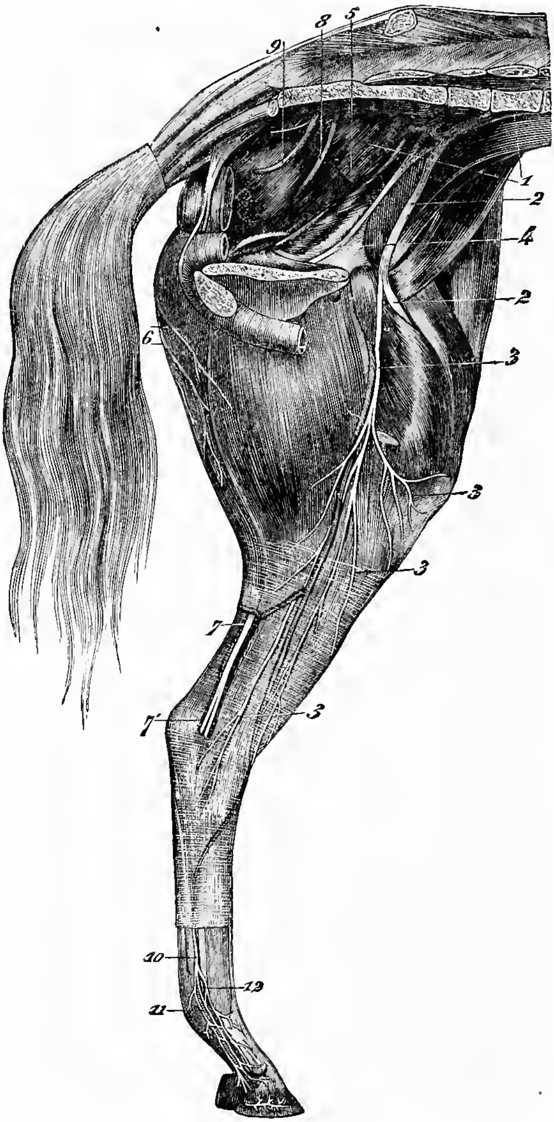
This is the largest of the branches arising from the anterior portion of the plexus. It descends between the psoas magnus and parvus, to the common conical extremity of the latter muscle and the iliacus, where it is covered by the sartorius; there it terminates in a wide tuft of branches, which, pass to the rectus femoris and vastus internus.

Below the sartorius, it successively emits two long branches, which deserve a particular description.

The first represents the fasciculus which, in Man, includes the crural *musculo-cutaneous branch.* We have named it the *accessory branch of the internal saphenic nerve.* It reaches the interstice between the sartorius and gracilis muscles, in crossing the crural vessels very obliquely forward. Leaving this space, it becomes subcutaneous, in forming numerous divisions which surround the saphena artery and vein.

The second, or *internal saphenic nerve,* passes at first between the sartorius and vastus internus, and parallel to the first, which is situated more inwardly and posteriorly. Near the inferior extremity of the interstice separating the sartorius and gracilis, it escapes and becomes subcutaneous, dividing into a number of filaments which meet those of the accessory nerve.

Fig. 473.



LUMBO-SACRAL PLEXUS AND INTERNAL NERVES OF THE POSTERIOR LIMB.

1, 1, Lumbo-sacral plexus; 2, anterior femoral nerve; 3, internal saphena nerve; 4, obturator nerve; 5, originating fasciculus of the great and small femoro-popliteal nerves; 6, superficial ramuscules of the posterior gluteal nerves; 7, great femoro-popliteal nerve; 8, internal pudic nerve; 9, hæmorrhoidal or anal nerve; 10, internal plantar nerve; 11, 12, its digital ramifications.

NOTE.—In the above figure is seen the posterior part of the plexus formed by the nerve-branches which pass through the three first subsacral foramina. That which escapes from the foramen between the sacrum and last lumbar vertebra, only gives a fine branch to this part of the plexus, and sends the greater portion of its fibres, in two cords, to the anterior part. This arrangement is not rare, and is generally seen, we believe, when there are only five lumbar vertebræ: as is remarked in the Ass and Mule, and sometimes in the Horse. It will, therefore, be understood that the nerve described by us as the first sacral pair becomes a lumbar pair.

These two branches communicate by deep or superficial anastomosing loops. Before leaving the space between the sartorius and gracilis, they give some slender filaments to these two muscles, particularly to the latter. Near their origin, they even distribute some to the iliacus. Becoming subcutaneous, their ramuscules cover the inner face of the thigh and leg; the longest of these accompany the saphena vein to the anterior aspect of the hock.

It sometimes—indeed, most frequently—happens that the internal saphena nerve and its accessory form only a single branch, the muscular or cutaneous divisions of which otherwise comport themselves exactly like the above. This is exemplified in the dissection represented in Fig. 473.

3. Obturator Nerve (Fig. 473, 4).

Situated underneath the peritoneum, to the inner side of the iliac vessels—which it accompanies to the origin of the obturator artery—this nerve follows the latter to the upper face of the pubes, and passes with it beneath the internal obturator muscle, to traverse the obturator foramen. In this way it arrives outside the pelvis, where it nevertheless remains deeply concealed by the muscular masses on the internal aspect of the thigh. Its terminal ramification are expended in the obturator externus, adductors of the thigh, pectineus, and gracilis. The branch to the latter muscle is the longest; it leaves the space between the pectineus and gracilis, and descends backwards on the internal face of the muscle to which it is distributed.

B. Posterior Portion.

4. Small Sciatic or Anterior and Posterior Gluteal Nerves.

The small sciatic nerve of the Horse is composed of several cords that issue from the pelvis by the upper part of the great sciatic notch, and which have been for a long time described as the anterior and posterior gluteal nerves.

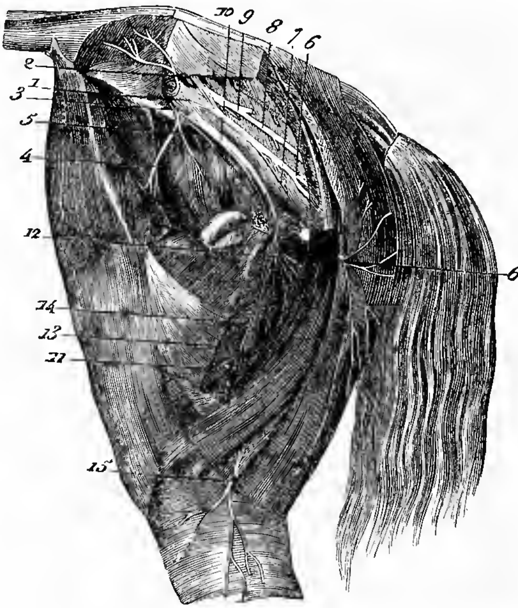
The *anterior gluteal* or *ilio-muscular nerves* (Fig. 474, 2, 3, 4, 5) are four or five in number, and arise either separately or in groups from the posterior portion of the lumbo-sacral plexus. They appear to be more particularly furnished by the two first sacral branches. All leave the pelvic cavity by the great sciatic opening, along with the anterior gluteal vessels. The principal branches are lost in the middle gluteal muscle. One of them (Fig. 474, 4) crosses the neck of the ilium above the superficial gluteal muscle, and passes outwards to be distributed to the tensor vaginæ femoris. The last, which is the most slender, descends to the external surface of the superficial gluteus, and is distributed in its substance (Fig. 474, 5).

The *posterior gluteal*, or *ischio-muscular nerves* (Fig. 474, 6, 6′, 8), are usually two in number—a superior and inferior.

The first escapes through the great sacro-sciatic notch, along with the femoro-popliteal nerves, and is situated on the external surface of the sciatic ligament. It passes backward, between this ligament and the middle gluteus, to beneath the anterior or croupal portion of the biceps femoris, in which it is distributed by several filaments. Besides these, it gives: 1. In passing beneath the gluteus middle, a slender, but constant filament to the posterior portion of that muscle. 2. Another, and more considerable branch, which bends round the posterior border of that muscle, to be directed forward and outward to the superficial gluteus

The second nerve, situated beneath the preceding, appears to be detached from the posterior border of the great sciatic nerve. It is placed on the external surface of the sciatic ligament, is directed backwards in passing below the croupal portion of the ~~rectus~~ femoris, and vastus externus and internus, passes through these muscles above the ischial tuberosity, descending underneath the sacral portion of the semitendinosus, soon to leave its deep track and become superficial. It escapes from between the latter muscle and the three just named, and is lost beneath the skin covering the posterior part of the thigh. Its deep portion gives

Fig. 474.



POSTERIOR PORTION OF THE LUMBO-SACRAL PLEXUS.

1, Conjoining fasciculi of the three first sacral nerves; 2, 3, 4, 5, anterior gluteal nerves; 6, 6', 8, posterior gluteal nerves; 7, 9, branches which traverse the great sciatic ligament, and communicate between the posterior gluteal branches and the divisions of the internal pudic nerve; 10, 11, 12, 13, great sciatic nerve and its crural branches; 14, small femoro-popliteal nerve; 15, its cutaneous or peroneal-cutaneous branch.

off collateral branches which reinforce the divisions of the internal pudic nerve, as well as filaments to the long branch of the semitendinosus muscle.

5. Great Sciatic or Great Femoro-popliteal Nerve (Figs. 201, 13; 475, 1, 2).

This enormous nerve (the largest in the body), issues by the great sciatic opening in the form of a wide band, which is applied to the external face of the sciatic ligament. Comprised at first between that ligament and the middle gluteus, it is directed backwards in passing over the fixed insertion of the gluteus internus, and arrives behind the gemelli and quadratus femoris muscles. On leaving this point, it is inflected to descend behind the thigh, where it is lodged in the muscular sheath formed for it by the biceps, the semitendinosus and membranosus, and the great adductor of the thigh. Arriving towards the superior extremity of the leg, it enters between the two bellies of the gastrocnemius muscle, passes along the posterior aspect of the perforatus muscle, and descends in the channel of the hock, beneath the tibial aponeurosis, following the internal border of the fibrous band that reinforces the tendon of the hock. It finally terminates at the calcis by two branches—the *external* and *internal plantar nerves.*

From the point at which the great sciatic enters between the bellies of the gastrocnemius muscle, and as far as the furrow of the calcis, this nerve corresponds to the branch named in Man the "internal popliteal"—a branch that is continued by the posterior tibial, which terminates in the plantar filaments.

In its long course, this nerve successively gives off: 1. The external popliteal nerve. 2. A branch to the muscles of the deep pelvi-crural region. 3. Another to the posterior crural muscles. 4. The external saphenous nerve. 5. A voluminous fasciculus to the muscles of the posterior tibial region. All these branches will be studied, more especially the external popliteal—which is so disposed in Solipeds, that Veterinary authorities have described it as a special trunk, by the name of the "small femoro-popliteal," and even as the "small sciatic nerve." We will afterwards pass to the terminal branch.

Collateral Branches of the Great Sciatic Nerve.

1. External popliteal or Small Femoro-popliteal Nerve.—This nerve separates from the great sciatic at the gemelli muscles of the pelvis. It is then directed forward and downward, proceeds between the biceps and the gastrocnemius muscles, and arrives outside the superior extremity of the leg, behind the lateral ligament of the femoro-tibial articulation, where it terminates by two branches—the *musculo-cutaneous*, and the *anterior tibial nerve.*

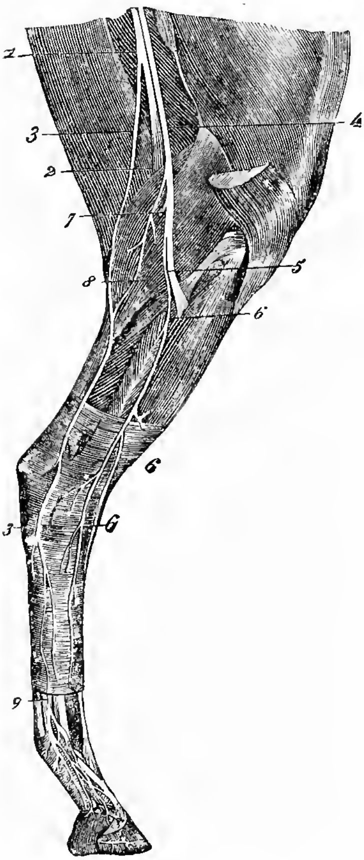
In the long course it follows from its origin to its bifurcation, the external popliteal nerve only furnishes a single collateral branch—this is the cutaneous nerve which is detached from the parent trunk above the gastrocnemius, and traverses the inferior extremity of the biceps to terminate by divergent ramuscules to the skin of the leg. It might be named the *peroneal-cutaneous branch.* Before becoming superficial, this cutaneous nerve gives off a small descending filament which goes to reinforce the external saphenous nerve, after creeping over the aponeurotic layer of the external portion of the gastrocnemius. This branch—which might be designated the *accessory of the external saphenous*—sometimes proceeds directly from the popliteal, as may be remarked in Fig. 475.

Terminal Branches.—These two branches stimulate the muscles belonging to the anterior tibial region, and endow the skin on the anterior surface of the foot with sensation.

The *musculo-cutaneous nerve* is situated beneath the tibial aponeurosis; it first sends a bundle of ramuscules to the lateral extensor of the phalanges, and continues to descend between that muscle and its congener—the anterior extensor—to the middle of the tibia. It then traverses the fibrous envelope of the tibial muscle, becomes subcutaneous, and gains the anterior face of the metatarsus, where it is lost in the skin. Some of its terminal filaments may be followed to the fetlock, and even beyond it (Fig. 475, 6).

The *anterior tibial nerve* passes in front of the preceding, to one side of the superior extremity of the leg, and then plunges beneath the anterior extensor of the phalanges, giving to that muscle and the flexor of the metatarsus short, but thick, ramuscules. It descends to the front of the tarsus, always covered by the anterior extensor of the phalanges, and placed at the external side of the anterior tibial vessels. When it arrives below the tibia, it lies immediately alongside the pedal artery, and follows it, in its metatarsal portion, to near the fetlock. It then separates from its satellite vessel—and passes on the side of the digit, where it ends in cutaneous filaments (Fig. 375, 5).

Fig. 475.



EXTERNAL NERVES OF THE POSTERIOR LIMB.

1, 2, Great sciatic nerve; 3, external saphenic nerve; 4, external popliteal nerve; 5, anterior tibial nerve; 6, musculo-cutaneous nerve; 7, origin of the peroneal-cutaneous branch; 8, accessory branch of the external saphenic nerve; 9, external plantar nerve with its divisions, which cover the digital artery and vein.

Among the ramuscules this nerve gives off in its course, are cited those to the pedal muscle.

2. Branches of the Muscles of the Deep Pelvi-crural Region.—This region comprises the obturator internus, gemelli, and quadratus femoris muscles. The nerve sent to them is long and attenuated; it is detached from the sciatic nerve at the middle of the supra-cotyloid ridge, and descends with that trunk behind the coxo-femoral articulation, to distribute its terminal divisions to the above-named muscles. The longest and thickest of these goes to the quadratus femoris. That passing to the obturator internus re-enters the pelvic cavity by the small sacro-sciatic notch, and ascends to the vicinity of the ilio-sacral articulation.

3. Branch to the Ischio-tibial, or Posterior Crural Muscles.—This branch is thick and short. It arises from the bend formed by the great femoro-popliteal nerve at the gemelli muscles, and soon divides into several ramifications which are distributed to the short portion of the biceps, the middle and inferior parts of the semitendinosus, and into the semimembranosus. Some of the filaments for the latter muscle pass between it and the adductor magnus, in which they partly terminate (Fig. 474, 12).

4. External Saphenic Nerve.—This branch commences at from 2 to 6 inches from the point where the great sciatic nerve dips between the two portions of the gastrocnemius muscle. It is placed on the external portion, and descends beneath the special aponeurotic layer covering that muscle, to the origin of the tendon of the hock. It then receives its *accessory nerve*—the reinforcing filament which comes from the cutaneous branch of the small femoro-popliteal nerve, and is prolonged beneath the tibial aponeurosis into the channel of the hock, accompanying the external saphenic vein, and following the external border of the fibrous band that goes to strengthen the tendo-Achillis. In this

way, it occupies the same situation outside the hock that the great sciatic does on the inner side. It afterwards passes over the tarsal region, and is expended on the outside of the metatarsus in several filaments, some of which descend to the outer aspect of the digit (Figs. 473, 11, 12; 475, 9).

5. Fasciculi to the Posterior Tibial Muscles.—This fasciculus is composed of numerous branches, which are detached together from the sciatic nerve on its passage between the two portions of the gastrocnemius muscle, in the form of a thick short trunk. The muscles of the superficial layer—the gastrocnemius, perforatus, and the thin fleshy band, improperly designated the "small plantaris" by Veterinarians—receive ramuscules which are remarkable for their large number and their shortn ss. Those of the deep layer are supplied by filaments from a single long and thick branch, which descends between the perforatus and the internal portion of the gastrocnemius. It may be remarked, that the filament going to the so-called small plantaris muscle passes underneath the external division of the gastrocnemius, outside the perforatus, and that, by its position, it exactly represents the soleus ramuscule in Man. We are, therefore —with Vicq-d'Azyr, Cuvier, and others—justified in naming this little muscle the soleus, instead of continuing to designate it the small plantaris, which appellation is given to another muscle.

6. In its course along the tendo-Achillis, the sciatic nerve emits some slender cutaneous filaments, which we do not consider worthy of further notice.

Terminal Branches.

Plantar Nerves (Fig. 473, 10, 12).—These two nerves enter the tarsal sheath, behind the perforans tendon, along with the plantar arteries. Towards the superior extremity of the cannon, they definitively separate from each other; the external is carried outwards between the precited tendon and the rudimentary metatarsal bone; the internal is placed with that tendon, and follows the posterior border of the inner metatarsal bone. Both afterwards descend on the fetlock, where they comport themselves like the analogous nerves of the anterior limb.

Differential Characters in the Lumbo-sacral Plexus of the other Animals.

As was the case with the brachial plexus, so with this; the differences observed being trifling in the upper part of the limb, but more numerous and important in the region of the foot, the complexity of arrangement varying with the species.

Ruminants.—The lumbo-sacral plexus of these animals is constituted by two lumbar and three sacral nerves, as in Solipeds; but the third sacral only gives a very fine filament, which reaches the second in passing downward and forward.

At the femoro-tibial articulation, the branches of the plexus are similar to those in the Horse. Below that articulation, the following disposition has been observed in the **Sheep**.

The *musculo-cutaneous branch* of the popliteal is long and thick. It descends on the anterior face of the metatarsus, and at the metatarso-phalangeal articulation bifurcates, the branches forming the dorsal collaterals of the digits. The *anterior tibial nerve* presents two branches parallel to the tibial vessels; one passes along the metatarsal region, and when it arrives at the bottom of the groove between the condyles of the metatarsus, it divides into two branches that constitute the deep collaterals of the digits; these collaterals furnish filaments to the posterior face of the digital region.

The *great sciatic* resembles that of Solipeds. Its terminal branches—or *plantar nerves*—differ from those of the Horse. in the absence of the transverse anastomosis that unites the two cords in the region of the tendons.

Pig.—The lumbo-sacral plexus of this animal is composed of two lumbar and three sacral nerves; reckoning, of course, as a sacral nerve, the trunk that escapes from between the last lumbar vertebra and the sacrum. The plexus may be divided into two portions, the first furnishing a femoral and an obturator nerve. The *internal saphenic branch of the femoral nerve* is long and voluminous; at its origin it is as large as the branch passing to the anterior muscles of the thigh, and it descends on the inner face of the metatarsus, forming the dorsal collateral of the internal digit.

The *great sciatic* is voluminous and round. The branches it gives to the muscles of the pelvis and femur are disposed nearly as in Solipeds and Ruminants; but differences are observed in the *external popliteal* and the terminal branches.

The *musculo-cutaneous nerve* reaches the metatarsal region, where it separates into three branches, which form the dorsal collaterals of the digits.

The *anterior tibial nerve* descends between the two principal metatarsals, and at the root of the middle digits divides to anastomose with the plantar nerves. Of these the external is small, and gives collaterals to the two external digits; the internal, the largest, descends between the two principal digits, where it bifurcates; above, it gives a branch to the internal digit.

Carnivora.—In these animals, the lumbo-sacral plexus is formed by the last four lumbar and the first two sacral.

The *crural* and *obturator nerves*, which arise from the fourth, fifth, and sixth lumbar nerves, offer nothing particular in their disposition.

The *internal saphenic* branch is as long as in the Pig; it passes to the internal face of the tarsus, lies alongside the fourth metatarsal bone, and forms the internal dorsal collateral of the fourth toe.

The *great sciatic* may be described as having, as in Man, two terminal branches which separate a little above the posterior face of the femoro-tibial articulation. The *external popliteal nerve* passes to the surface of the external gastrocnemius, enters between the common long flexor of the toes and the long lateral peroneal muscle, where it bifurcates. The *musculo-cutaneous* branch descends beneath the latter muscle to the lower third of the leg, when it becomes superficial, and, accompanied by a vein, is lodged in the interspace between that muscle and the anterior tibial; it passes in front of the tarsus, and reaches the upper part of the metatarsus, where it divides into three divisions. It must be mentioned that at the tibio-tarsal articulation is thrown off a very fine cord, which is directed outwards, and forms the external dorsal collateral of the first toe. Each of its three terminal branches courses along an intermetatarsal space, and at the metatarso-phalangeal articulations separates into two filaments, whence results the following distribution: the external branch forms the internal dorsal collaterals of the first toe and external of the second; the middle constitutes the internal dorsal collaterals of the second toe and external of the third; lastly, the internal furnishes the internal dorsal collaterals of the third toe and external of the fourth. The *anterior tibial nerve* accompanies the artery of that name, descends along the external face of the tibia, and terminates in two branches at the tarsus. Of these, one is distributed to the tarsal articulations and the pedal muscle: the other, internal, enters the intermetatarsal space, and at the corresponding metatarso-phalangeal joints anastomoses with the internal branch of the musculo-cutaneous nerve, and is lost in the same parts. The *internal popliteal* forms the second terminal branch of the great sciatic nerve, and in the Dog and Cat represents that portion of the latter which, in the Horse, is situated behind the femoro-tibial articulation. It is continued by the *posterior tibial nerve*, which terminates by the two plantar nerves. During its course, the external popliteal furnishes articular and muscular filaments, as well as cutaneous twigs subsequently; among the latter may be mentioned the *external saphenic*, which arises by two branches, and is expended behind the malleolus, at the outer side of the tarsus. The *plantar nerves* are external and internal; the latter lies at the inner border of the tendon of the superficial flexor muscles of the phalanges, and when it joins the middle of the metatarsus, it detaches a fine filament that forms the internal plantar collateral of the fourth toe; it then passes obliquely towards the first toe, at the deep face of the above-named tendon, and successively gives off three filaments—one for each intermetatarsal space. These filaments anastomose with the terminal branches of the external plantar, at the metatarso-phalangeal articulations; the first two filaments supply the large cushion of the paw.

The *external plantar nerve* passes between the two flexor tendons of the toes, where it gives a filament that constitutes the external plantar collateral of the first toe. It is afterwards placed outside the deep flexor, then enters beneath the short flexor and divides into several branches—muscular and digital. Each of the latter—three in number—passes into a corresponding interosseous space and bifurcates at the metatarso-phalangeal articulations, receiving filaments from he internal plantar, and forming the following plantar collaterals:

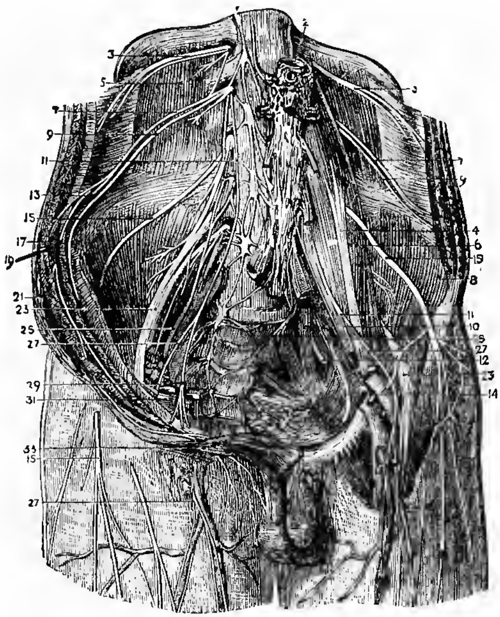
the internal of the first toe, internal and external of the second, internal and external of the third, and external of the fourth digit.

COMPARISON OF THE LUMBO-SACRAL PLEXUS IN MAN WITH THAT OF ANIMALS.

It is usual, in human anatomy, to describe a lumbar and a sacral plexus.

The *lumbar plexus* is constituted by the anastomoses of the anterior branches of the five lumbar nerves;[1] these are united by fine filaments, which are not intricately associated. The divisions of this plexus are distinguished as *collateral* and *terminal branches*. The first, destined to the upper part of the limb and the skin covering the external genital organs, are represented in Solipeds by the ramifications of the lumbar nerves, which have been separately described. The terminal branches are the *obturator crural*, and *anterior femoral* (or *anterior crural*). There is nothing to be said respecting the obturator nerve; it leaves the pelvis by the obturator foramen, as in all the animals mentioned. The crural has been described as having four terminal branches: the *internal* and *external musculo-cutaneous*, the *nerve of the triceps crureus* (*muscular branch*), and the *internal saphenous*. The two *musculo-cutaneous branches* have their analogue in the Horse, in the filament we have named the accessory branch of the internal saphenic. The nerve of the triceps is expended in the anterior rectus, and the vastus internus and externus. The saphenic descends between the muscles of the inner aspect of the thigh, beneath the aponeurosis, and becomes superficial at a short distance from the condyle of the femur, giving a patellar branch that divides in the skin of the knee, and a tibial branch that is expended on the inner face of the tarsal articulations and the foot.

Fig. 476.



LUMBAR PLEXUS OF MAN.

1, Right gangliated cord of sympathetic; 2, abdominal aorta; 3, 3, last dorsal nerves; 4, psoas parvus; 5, quadratus lumborum; 6, psoas magnus; 7, 7, ilio-hypogastric nerves; 8, iliacus internus; 9, 9, ilio-inguinal nerve; 10, lumbo-sacral nerve; 11, genito-crural nerve; 12, gluteal nerve; 13, iliac branch of ilio-hypogastric nerve; 14, sacral plexus; 15, 15, 15, external cutaneous nerves; 17, transversalis abdominis; 19, obliquus internus; 21, obliquus externus; 23, 23, anterior crural nerves; 25, 25, obturator nerves; 27, 27, crural branch of genito-crural nerve; 29, genital branch of genito-crural nerve; 31, external iliac artery; 33, external abdominal ring.

The *sacral plexus* comprises the first three sacral nerves, to which is added a lumbo-sacral branch furnished by the lumbar nerves, and a fine filament that ascends from the fourth sacral.

Ten collaterals and a terminal branch arise from this plexus.

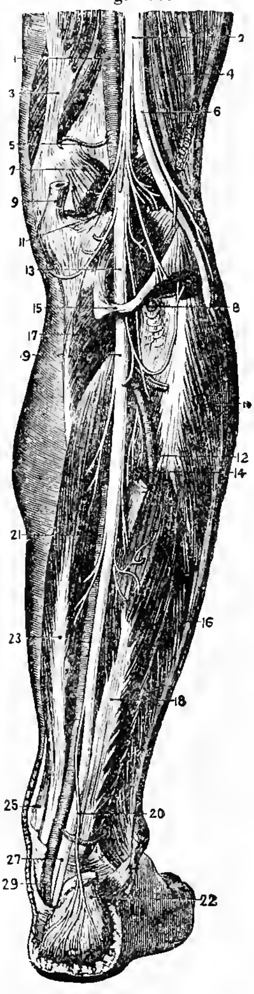
The *collateral branches* are divided into intra-pelvic and extra-pelvic: they are five in each group. The first are destined to the muscles of the inner aspect of the pelvis, and to those of the perineum and the skin of this region. The second are distributed to the muscles on the outer aspect of the pelvis, and the skin on the posterior face of the thigh. They are—

1. *Visceral branches* that descend on the sides of the rectum and are lost in the hypogastric plexus. 2. *Nerve of the elevator of the anus*. 3. *Hæmorrhoidal* or *anal nerve*. 4. *Nerve of the internal obturator* that appears to arise, in the Horse, from the sciatic trunk. 5. *Internal pudic*, which has been described with the sacral nerves. In Man this nerve leaves the pelvis

([1] Wilson says the four upper lumbar nerves and the last dorsal; Heath gives the same constitution.)

by the great sciatic notch (or foramen), and returns to it by the lesser; within the ischiatic

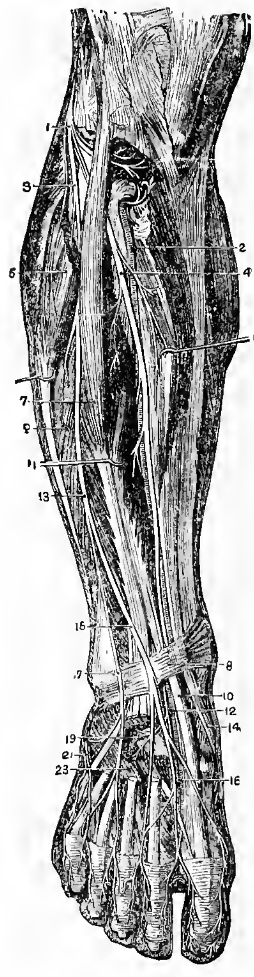
Fig. 477.



NERVES AT THE POSTERIOR ASPECT OF HUMAN LEG.

1, Popliteal artery; 2, great sciatic nerve; 3, adductor magnus; 4, biceps; 5, superior internal articular artery; 6 external popliteal nerve; 7, gastrocnemius (cut); 8, anterior tibial artery; 9, tendon of semimembranosus; 10, peroneus longus; 11, sural arteries and nerves; 12, peroneal artery; 13, internal popliteal nerve; 14, tibialis posticus; 15, portion of soleus; 16, peroneus brevis; 17, popliteus; 18, flexor longus pollicis; 19, posterior tibial nerve; 20, calcanean branch of posterior tibial nerve; 21, posterior tibial artery; 22, tendo-Achillis; 23, flexor longus digitorum; 25, tendon of tibialis posticus; 27, plantar nerves; 29, plantar arteries.

Fig. 478.



NERVES AT THE FRONT ASPECT OF HUMAN LEG.

1, External popliteal nerve; 2, anterior tibial artery; 3, musculo-cutaneous nerve; 4, anterior tibial nerve; 5, peroneus longus; 6, tibialis anticus; 7, extensor longus digitorum; 8, anterior annular ligament; 9, peroneus brevis; 10, tendon of extensor proprius pollicis; 11, extensor proprius pollicis; 12, dorsal artery of foot; 13, point at which the musculo-cutaneous nerve pierces the fascia and bifurcates; 14, tendon of tibialis anticus; 15, internal branch of musculo-cutaneous nerve; 16, cutaneous branch of anterior tibial nerve; 17, external branch of musculo-cutaneous nerve; 19, deep branch of anterior tibial nerve; 21, external saphenic nerve; 23, exteusor brevis digitorum.

tuberosity it divides into two branches—an inferior or *perineal*, and a superior or *dorsalis penis nerve.* The latter is placed on the dorsum of the penis, and reaches the mucous membrane of the glans and prepuce; the former does not go beyond the muscles and integuments of the perineum. 6. The *superior gluteal nerve.* 7. *Nerve of the pyramidalis.* 8. *Nerve of the superior gemellus.* 9. *Nerve of the inferior gemellus and quadratus cruralis.* 10. The *small sciatic*, or *inferior gluteal nerve*, the inferior or femoral branch of which is very long, descending, as it does, to the middle of the posterior face of the thigh, beneath the crural aponeurosis, to the popliteal space, where it becomes superficial, and terminates in the skin of the upper portion of the leg.

The *terminal branch* of the sacral plexus forms the *great sciatic nerve*, the distribution of which is the same as that of Carnivora. The collateral ramuscules of the great sciatic are the branch of the long portion of the biceps; the semitendinosus and semimembranosus branch; the branch to the great adductor; and, lastly, that to the short portion of the biceps. It terminates by the external and internal popliteal.

The *musculo-cutaneous* and *anterior tibial*, continuations of the external popliteus, comport themselves almost the same as in the Dog. They form dorsal collaterals to the third, fourth, and fifth toes, as well as to the second.

The *internal popliteal* presents an external saphenous nerve that passes along the external border of the foot, and has, in addition, a branch that ascends on the dorsum of that organ. The external saphenous furnishes the dorsal collaterals to the first toe, and the external collateral to the second. The *posterior tibial nerve* continues the internal sciatic in the leg; it terminates in the *plantar nerves.* The internal plantar furnishes the collateral nerves to the fifth, fourth, and third toes, and the internal collateral of the second toe. The external divides into three branches: the two superficial branches form the collaterals of the first toe, and the external collateral of the second; the deep branch passes inwards, behind the interosseous muscles, and is expended in those of the fourth space, after giving filaments to the oblique abductor of the large toe, transverse abductor, last two lumbricales, to the interosseous, and very fine filaments to the articulations of the tarsus with the metatarsus.

It will therefore be seen, that, in Man, the branches of the deep trunk of the external plantar join those of the internal plantar, to form the collateral nerves.

CHAPTER III.

THE GREAT SYMPATHETIC NERVOUS SYSTEM.

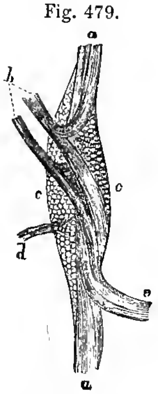
PREPARATION OF THE GREAT SYMPATHETIC.—*The same subject ought to suffice for the preparation of this, as well as for the pneumogastric and spinal nerves.* After placing the animal in the first position, the intestines are removed, one of the posterior limbs cut off, and the greater portion of the os innominatum cleared away by sawing through the symphysis pubis and the neck of the ilium; the dissection of all the abdomino-pelvic portion of the system, and that of the terminal branches of the pneumogastric nerve, is then proceeded with. The anterior limb of the same side should be afterwards detached, the scapula having been previously sawn across its middle part, and the thorax thrown open by the ablation of the entire costal wall, in sawing through the sternal cartilages below, and the ribs above, at their superior extremity. All the thoracic portion of the ganglionic nervous apparatus, and the pneumogastric nerves, may then be prepared. Nothing more remains to be accomplished except the dissection of the sympathetic and the vagus nerve in the cervico-cephalic region, with that of the spinal nerve; this operation is not attended with any difficulty, and should be preceded by the extirpation of a branch of the inferior maxilla. It is useful to inject the arteries previously; as then the filaments of the sympathetic that lie alongside the vessels of the different organs in the abdominal cavity can be more easily followed.

The *great sympathetic*, also named the *trisplanchnic system* (σπλανχνον, an intestine or viscus), because of its position and destination, is the nervous apparatus of the organs of vegetative life.

As has been already shown in the general consideration of the nerves and the whole nervous system, this apparatus has for its base two long cords extending from the head to the tail, underneath the vertebral column, and to the right and left of the mesian line. Towards the last sacral vertebra, a portion of these two cords converge towards each other, and lie beside the mesial coccygeal artery. Some anatomists think that the great sympathetic does not stop at this point, but is prolonged beneath the coccygeal vertebræ, where it enters a ganglion that has been described of late years as the "coccygeal gland" (*Luschka's gland*); this, however, is not a nerve-ganglion.

Each cord presents on its course numerous ganglia, to which it owes its chain-like aspect; they are usually elliptical in shape, though they may also be round or semilunar; some are studded with prolongations at their borders. Beneath each of the regions of the spine, these ganglia are equal in number to the vertebræ, with the exception of the cervical region, in which there are only two—one at the top, the other at the bottom, of the neck.

Fig. 479.



SYMPATHETIC GANGLION FROM A PUPPY.

a, a, Trunk of the sympathetic nerve; *b*, communicating branches from a spinal nerve; these divide into two fasciculi which pass upwards and downwards in the trunk; *c, c*, the ganglion composed of ganglion cells; *d*, small branch, probably destined to accompany an artery; *e*, visceral branch.

To this chain arrive *afferent branches*, by the union of which it is constituted; these branches are furnished by the nerves of the medulla oblongata and the inferior spinal branches, except those of the coccygeal region. The afferent branches join the sympathetic at each ganglion; but as there are only two ganglia in the region of the neck, the afferent filaments of the cervical nerves are grouped in such a manner as to reach the superior and inferior ganglion.

Those nerves which are given off from the ganglia to be distributed to the viscera, are named the *efferent* or *emergent branches*. They are interlaced around the arteries to reach their destination, forming *plexuses* on the surface of these vessels.

This general idea of the disposition of the great sympathetic is sufficient to show that its double ganglionic chain does not represent two particular nerves arising at one determinate point, and ending at another. Properly speaking, they have neither origin nor termination; they are always giving off branches, which are as frequently replaced by others. In this way they might be compared to the median spinal artery, which offers somewhat the same mode of constitution—with its *afferents* supplied by the spinal branches from the intervertebral foramina, and its *efferents* destined to the substance of the spinal cord.

STRUCTURE.—The ganglia of the great sympathetic differ but little in their structure from the spinal ganglia, which have been already described. They have an envelope of connective tissue, which sends very fine septa into their interior. In the spaces are cells a little smaller and paler than those of the spinal ganglia; they are round, or furnished with poles that bring them into communication with the afferent and efferent nerve-tubes; there are also, in the ganglia, tubes which only pass through it, and merely lie beside the cells.

The *afferent branches of the ganglia* have not the white tint of the cerebro-spinal nerves; they are named the *grey nerves*. They owe their colour to the *fibres of Remak*, which they contain in large quantity. With these nucleated fibres are associated fine double-contoured fibres—myelin fibres—which proceed from the *communicating rami*, or afferent filaments supplied by the spinal nerves; these fibres often leave the ganglia to pass directly to organs.

In describing the sympathetic chain, it is divided into five sections: a *cranial*, *cervical*, *dorsal*, *lumbar*, and *sacral*.

1. Cranial Portion of the Sympathetic.

This is composed of the *spheno-palatine*, *ophthalmic*, and *otic ganglia*, all of which communicate with the superior cervical ganglion. Their description has been given with that of the fifth cranial pair of nerves.

2. Cervical Portion of the Sympathetic.

The cervical section of the ganglionic chain is formed by two large ganglia placed one at the top, the other at the bottom, of the neck, and united to each there by an intermediate cord.

A. Superior Cervical or Guttural Ganglion (Fig. 480, 1).—This ganglion is a very elongated fusiform body, lying beside the internal carotid artery, comprised with it in a particular fold of the membrane forming the guttural pouch, and therefore situated in front of the transverse process of the atlas, in proximity to the glosso-pharyngeal, pneumogastric, spinal, and hypoglossal nerves, as well as the inferior branch of the first cervical pair. All these nerves communicate with the ganglion by slender filaments, and in this way form around it a veritable plexus, which has been designated the *guttural plexus* by Veterinary Anatomists.

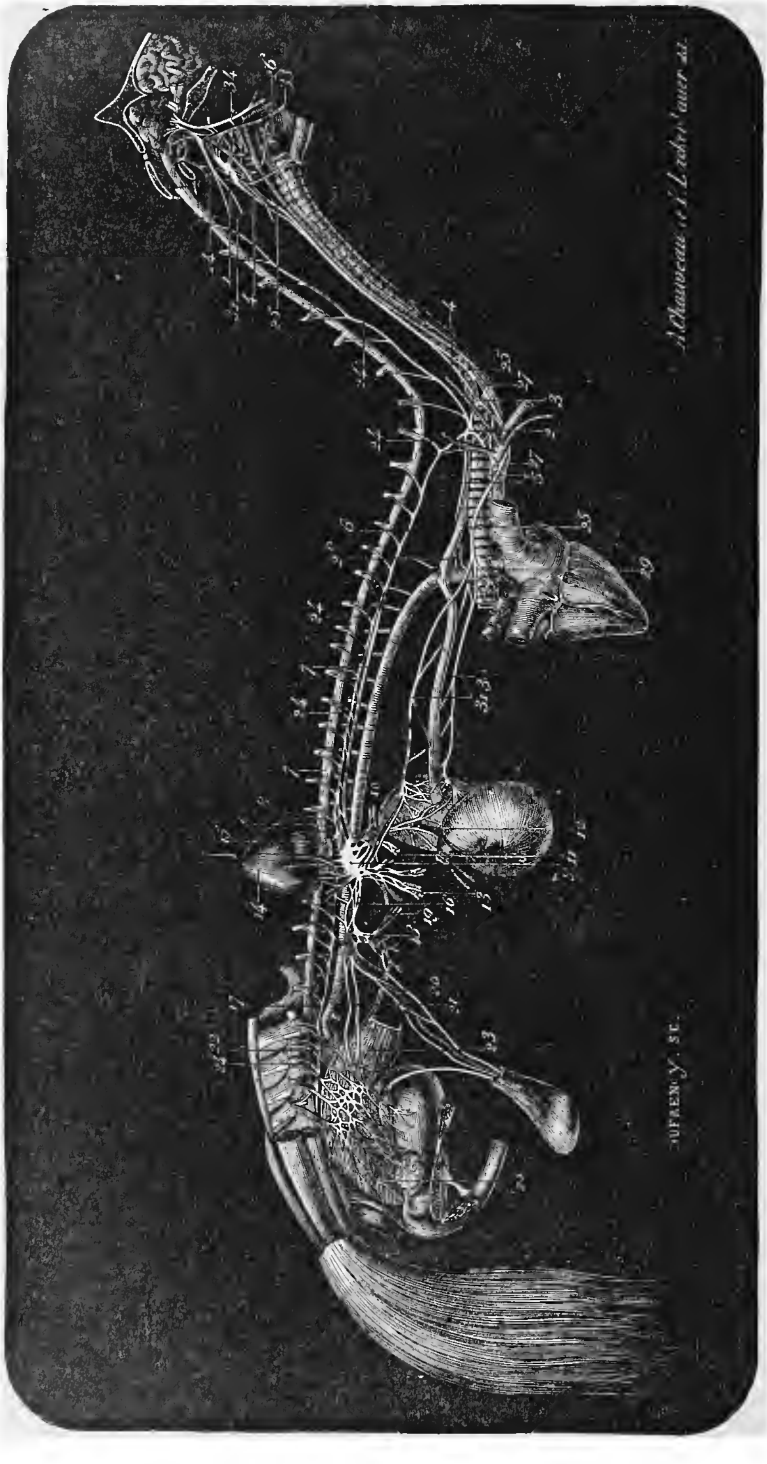
Afferent Branches.—These are communicating filaments belonging to the nerves already enumerated. They do not possess sufficient importance to merit particular mention. We may notice the existence of the filaments supplied by the inferior branches of the first four cervical nerves.

Efferent Branches.—These are: 1. Branches accompanying the internal carotid artery into the cranium. 2. A thick fasciculus which reaches the origin of the three terminal divisions of the common carotid. 3. Small filaments to the membrane of the guttural pouch and the wall of the pharynx.

The following are the principal anatomical characters of these three orders of branches:—

a. The *satellite branches of the internal carotid artery* arise at the superior extremity of the ganglion. They may vary in number. Two are generally found, of unequal volume—a *posterior*, and an *anterior*, which is the smallest. They interlace around the internal carotid in anastomosing with each other, and with that vessel enter the cavernous sinus, where they form, by their divisions, a little plexiform apparatus named the *cavernous plexus*, the various branches of which connect it with several of the cranial nerves. Among these branches are remarked: 1. Some filaments joined to analogous filaments from the opposite side, on the transverse anastomosis which unites the two internal carotids in the cavernous sinus. 2. A branch lying beside the great petrosal nerve, and concurring in the formation of the Vidian nerve, which enters the spheno-palatine ganglion. 3. A ramuscule going to the ophthalmic ganglion, in company with fibres from the ophthalmic branch of the fifth pair. 4. Several filaments passing to the Gasserian ganglion. 5. Branches which mix with the fibres of the three motor nerves of the eye.

Fig. 480.



THE SYMPATHETIC SYSTEM (PARTLY THEORETICAL).

The spinal cord has been deprived of its bony case throughout the whole extent of its cervical, dorsal, and lumbar portions.

b. The *inferior carotid fasciculus*, sent to the terminal extremity of the common carotid, escapes from the inferior part of the guttural ganglion. Frequently at its origin it is only a thick cord, but ordinarily it is composed, from its commencement, of several branches bound to one another by communicating filaments. Reaching their destination, these branches meet ramuscules emanating from the glosso-pharyngeal and pneumogastric nerves, and anastomose with them to form, around the origin of the three terminal branches of the common carotid, the so-called *carotid plexus*, the ramifications of which almost exclusively follow the external carotid, the greater part being distributed to the glands and salivary lobules. In Man, the division which follows the spheno-spinal artery passes to the otic ganglion; the same takes place, no doubt, in animals.

c. The *guttural* or *pharyngeal filaments*, arising from the anterior border of the ganglion and the inferior carotidean fasciculus, are generally very delicate. Those which reach the superior wall of the pharynx concur, with the glosso-pharyngeal and the pneumogastric, to form the *pharyngeal plexus*.

B. Intermediate Cord of the Two Cervical Ganglia.—This cord leaves the inferior extremity of the superior cervical ganglion, lies close beside the pneumogastric nerve, which always exceeds it in volume, and descends to the entrance of the thorax, where it separates from the vagus nerve, and joins the inferior cervical ganglion. It neither receives nor gives off any branch in its course.

C. Inferior Cervical Ganglion (Fig. 480, 2).—Generally thicker than the superior, this ganglion is placed within the costal insertion of the inferior scalenus. The right, always a little more anterior than the other, is applied immediately against the side of the trachea. That of the left side is separated from it by the œsophagus. Both are related, externally, to the vertebral artery.

The inferior cervical ganglion is very liable to vary, and become irregular in form. It is sometimes lenticular, at others more or less elongated, always stellate, and not unfrequently double. In the latter case—which is perhaps more frequent in the left than the right—its two portions are distinguished into anterior and posterior. The last forms the *inferior cervical ganglion*, properly called (Fig. 480, 2); the former is much smaller, and is bound to the other by a wide and short greyish band, constituting what has been designated in Man the *middle cervical ganglion* (Fig. 480, 3).

In front, the ganglion which we are describing receives the cord intermediate

1 to 2, *Cervical portion of the sympathetic chain;* 1, superior cervical ganglion, in the middle of the guttural plexus; 2, inferior cervical ganglion; 3, middle cervical ganglion; 4, intermediate cervical cord, intimately united at its middle portion with the pneumogastric nerve; 5, cardiac nerves; 6, *dorsal portion of the sympathetic chain;* 7, great splanchnic nerve; 8, lesser splanchnic nerve; 9, semilunar ganglion, centre of the solar plexus; 10, portion of the hepatic artery encircled by its splexus; 11, the splenic artery, ditto; 12, the gastric artery, ditto; 13, the anterior mesenteric artery, ditto; 14, kidney, elevated, receiving the renal plexus; 15, the supra-renal capsule with its plexus; 16, lumbo-aortic plexus; 17, *lumbar portion of the sympathetic chain;* 18, posterior mesenteric plexus; 19, branches from it passing to the anterior mesenteric plexus; 20, spermatic plexus; 21, branches going to the pelvic plexus; 22, *sacral portion of the sympathetic chain;* 23, pelvic plexus; 24, afferent branches furnished to the sympathetic by the spinal pairs; 24′, the cord which receives six of the cervical ramuscules; 25, *pneumogastric nerve;* 26, superior laryngeal (the pharyngeal branch is seen to be detached from the pneumogastric a little below); 27, inferior laryngeal nerve of the right side; 28, that of the left side at the point where it bends round the arch of the aorta; 29, nerves of the bronchial plexus; 30, superior œsophageal branch; 31, inferior ditto; 32, *spinal nerve;* 33, hypoglossal nerve; 34, glosso-pharyngeal nerve (represented too thick).

to the two ganglionic enlargements in the region of the neck, either directly, or through the medium of the middle cervical ganglion, when that is present. It is continued backwards with the dorsal portion of the sympathetic chain.

Afferent Branches.—These are two, proceeding from the cervical pairs.

One is a thick nerve, satellite to the cervical vertebral artery (sometimes named the *vertebral plexus*), and lodged with it in the foramina of the cervical vertebræ; it is formed by filaments emanating from the second, third, fourth, fifth, sixth, and seventh pairs of cervical nerves, and thus carries in a mass, to the sympathetic, the contingent of afferent nerve-fibres of the majority of these nerves (Fig. 480, 24′).

The other branch is an isolated one, proceeding from the eighth cervical pair.

Besides these afferents, there ought to be noticed the filaments sent by the pneumogastric nerve, and which join the middle cervical ganglion, when it is present (*see the description of the pneumogastric nerve*).

Efferent Branches.—These are detached from the posterior and inferior parts of the ganglion, and for the most part proceed to the heart. Some extremely fine filaments go to the anterior mediastinum, or pass on to the collateral arteries of the brachial trunk.

The *cardiac nerves* (Fig. 480, 5) cross the base of the pericardium, alongside the common aorta, and are then distributed to the tissue of the auricles and ventricles. Some follow the divisions of the pulmonary artery, and concur in the formation of the bronchial plexus.

To arrive at the heart, these nerves accompany the axillary arteries and the trachea, giving origin, on the inferior face of the latter, to a very large fasciculus, named, in Veterinary anatomy, the *tracheal plexus*; this is single, and is traversed from behind to before by the two recurrent nerves, which give or receive from it numerous filaments.

The *cardiac nerves* come from the right and left sides. In the Horse they usually have the following disposition :—

a. On the *left side* are four nerves, two of which—very fine—proceed from the middle cervical ganglion and disappear on the vessels which arise from the convexity of the brachial artery. Of the other two, one is superficial, the second deep. The former—the most voluminous—begins as a filament from the middle cervical ganglion, and passes backwards and downwards, forming an arching anastomosis below the brachial artery with a branch detached from the inferior cervical ganglion, then lies beside the following. The deep nerve is at first formed of three elements: 1. Medullary fibres furnished by the spinal pairs. 2. A ramuscule from the cervical cord of the sympathetic. 3. A slender filament which leaves the left pneumogastric, near the entrance to the thorax. It places itself in the direction of the heart, adheres to the superficial nerve, is inflected on the concavity of the brachial artery, margins that vessel on the left, and insinuates itself between the aorta and the pulmonary artery. At this point, these nerves are distributed to the heart and large vessels, a branch passing beneath the right auricle and entering the cardiac muscle; a second branch ramifies on the commencement of the pulmonary artery and on the right ventricle; two other grey, plexiform branches anastomose more or less between the aorta and pulmonary artery, and unite beneath the arch of the aorta, with a nerve from the right side, then descend in the vertical groove on the heart, to be expended in the left ventricle; lastly, other ramuscules, parallel to the pneumogastric, go to the pulmonary artery and aorta.

b. On the *right side* are two principal cardiao nerves, and four secondary filaments. The first cardiac nerve is a long branch that arises at the middle cervical ganglion. It is formed by fibres from the sympathetic, and by a fasciculus furnished by the right pneumogastric, at the entrance to the thorax; it also probably receives medullary fibres through the medium of a communicating branch between the middle and inferior ganglion. This nerve is reinforced by two filaments that proceed from the inferior cervical ganglion, and sometimes from the second middle ganglion, one of which—the posterior—is itself reinforced by a left sympathetic filament that reaches its destination in passing along the recurrent nerve. When it is entirely constituted, the first nerve creeps on the base of the heart, turns round the arch of the aorta, and mixes its terminal fibres with those of the left cardiac nerves. The second right cardiac nerve is formed by the union of three branches that arise successively from the corresponding pneumogastric, behind the dorsal artery, along the right side of the trachea. This nerve attaches itself to the sympathetic in the dorsal region, by three branches that approach the latter below the first, fourth, and sixth ribs.

When the second right nerve arrives above the termination of the anterior vena cava, it divides into two branches; one of these goes to the roof of the auricles, and the other—joined by a filament from the pneumogastric—is expended by numerous ramuscules, on the surface of the left ventricle; some even extend to the right ventricle.

The four secondary filaments are echeloned on the portion of the pneumogastric included between the entrance to the thorax and the division of the bronchi, These filaments go to the large vessels, and into the walls of the heart.[1]

3. Dorsal Portion of the Sympathetic.

The cord represented by this portion of the sympathetic chain leaves the inferior cervical ganglion, and extends from before to behind, towards the diaphragm, passing beneath the superior extremities of the ribs—or rather, below the vertebro-costal articulations, against which it is maintained by the pleura—and crossing the intercostal arteries. It is continued in the abdominal cavity by the lumbar portion, after passing through the arch in the superior border of the diaphragm, along with the psoas parvus.

Along its course, this cord exhibits, at each intercostal space, a small fusiform ganglionic enlargement—seventeen in all. The two or three first are most frequently absent; but then the anterior extremity of the nerve has for some extent the appearance of a ribbon-shaped ganglion, which seems to be due to the elongation, posteriorly, of the inferior grey mass of the cervical portion.

Afferent Branches.—Furnished by the inferior branches of the dorsal nerves, these ramuscules number from one to three for each ganglion. In proceeding from the intervertebral foramina to the sympathetic, they traverse the superior extremity of the intercostal space, passing sometimes behind, sometimes before, the arteries of that name.

Efferent Branches.—A very few delicate branches pass to the pleuræ; those which demand notice are the *great* and *lesser splanchnic nerves*.

[1] To sum up—the cardiac nerves contain fibres from the pneumogastrics. The right pneumogastric furnishes a greater number to them than the left. Perhaps to this circumstance is due the predominance of the right vagus in the phenomena attending arrest of the heart's action (Arloing and Tripier, "Contribution a la Physiologie des Nerfs Vagues," in *Archiv. de Physiologie Nor. et Path.* 1872).

a. Great splanchnic nerves (Fig. 480, 7).—This commences to be detached from the dorsal chain towards the sixth or seventh ganglion, is directed backwards by the external side of that chain, receives an accessory branch from each of the enlargements it passes by, except the last two or three, and enters the abdominal cavity through the arch of the psoas parvus, where it usually looks like a small ganglionic mass; after which, it is inflected inwards, and terminates on the side of the aorta, between the cœliac and mesenteric trunks, by a second and enormously developed mass—the *solar ganglion.*

The two *solar*, or *semilunar ganglia*, as they have also been designated, and which are the largest in the body, are elongated from before to behind, and flattened above and below. They communicate with one another by means of a wide and thick greyish cord, which encircles, posteriorly, the trunk of the great mesenteric artery, and by a multitude of filaments which pass from the left to the right, in front of that vessel. From this arrangement results a single plexus, situated at the inferior face of the aorta, between the origin of the two precited arterial trunks.

This plexus, named the *solar plexus*, receives some branches from the superior œsophageal cord of the pneumogastric nerve. It subdivides on its periphery into several secondary plexuses, which leave, as from a centre, the principal network; the ramifications of this—very large and numerous—proceed to the neighbouring organs in accompanying the arterial divisions, around which we see them interlacing and anastomosing in a very complicated manner. It is for this reason that there have been described separately: 1. *A gastric plexus*, going to the stomach, on the parietes of which its branches anastomose with those of the pneumogastrics. 2. *A hepatic plexus*, for the liver, duodenum, pylorus, and pancreas. 3. *A splenic plexus*, one part of which passes to the spleen, the other to the stomach. 4. *An anterior mesenteric plexus*—the most considerable of all—is distributed to the same organs as the artery of that name. 5. *A renal* and a *supra-renal plexus*—double, and scarcely distinct from each other—send their terminal divisions to the kidneys and supra-renal capsules. The terminations of the filaments of these plexuses have been already described in the Splanchnology.

It is necessary to add to this rich nervous apparatus, the *lumbo-aortic plexus*, formed by the large and numerous branches which spring from the solar plexus behind the great mesenteric artery, creep along the sides and the inferior face of the aorta, frequently anastomose with each other, and reunite at the posterior mesenteric plexus.

b. Lesser splanchnic nerve (Fig. 480, 8).—This branch is composed of two or three filaments that emanate from the last subdorsal ganglia, and which, instead of joining the great splanchnic nerve like the others, with which they communicate by one or two fine divisions, collect in a short thin cord, the ramifications of which pass directly into the solar plexus, or are confounded with the nerves of the kidney and the supra-renal capsule.

4. Lumbar Portion of the Sympathetic.

This is a cord similar to that of the dorsal portion, and provided with fusiform ganglionic enlargements equal in number to the pairs of lumbar nerves. This cord is applied against the psoas parvus, near the common inferior vertebral ligament, and is covered on the left by the aorta, on the right by the posterior vena cava. It is directly continued by the sacral portion of the sympathetic chain, at the lumbo-sacral articulation.

Afferent Branches.—Furnished by the inferior branches of the lumbar nerves, these ramuscules comport themselves exactly like those of the dorsal region.

Efferent Branches.—These are short filaments, analogous to those which, by their union, constitute the splanchnic nerves. Their number is not constant, and is generally less than that of the ganglia. Two or three join the lumbo-aortic plexus; the others reach the origin of the small mesenteric artery, anastomose around it with the posterior extremities of the branches of that plexus, and thus form another single network, designated the *posterior mesenteric plexus* (Fig. 480, 18).

This plexus, in the centre of which is a more or less voluminous ganglion, sends to the various branches of the small mesenteric artery ramifications for the walls of the small colon and the rectum.

It supplies besides: 1. Two or three large branches which follow the posterior mesenteric vein, and join the anterior mesenteric plexus, after throwing some divisions into the colic mesentery (Fig. 480, 19).

2. Satellite branches to the two *spermatic arteries*, constituting the plexus of that name (Fig. 480, 20).

3. Two or three long divisions (Fig. 480, 21) which enter on each side of the pelvis, by passing beneath the external face of the peritoneum, and reach the lateral plane of the rectum, where they meet the filaments emanating directly from the inferior sacral nerves. From the anastomosis of these divisions results a rich nervous network, called in Man the *hypogastric plexus*, and which we have designated the *pelvic plexus*; this network supplies all the organs contained in the pelvic cavity (Fig. 480, 23).

5. Sacral Portion of the Sympathetic.

A continuation of the lumbar cord, this portion of the sympathetic chain is situated beneath the sacrum, to the inner side of the inferior sacral nerves. It offers four very elongated ganglia, which communicate with these nerves by one or more filaments, and which give rise to several very fine ramuscules that are lost in the connective tissue on the inferior face of the sacrum.

Its posterior extremity, which terminates behind the great sympathetic, does not always comport itself in the same manner. We sometimes see it become attenuated to a very delicate ramuscule, which passes on to the mesian coccygeal artery, and anastomoses with that of the opposite side. But sometimes, also, this ramuscule cannot be distinguished, and the sub-sacral cord seems to be abruptly terminated by the filament of communication from the last sacral pair.

Functions.—The functions of the sympathetic are as yet incompletely known, notwithstanding the labours of many physiologists, at whose head must be placed Claude Bernard. In a physiological condition, this nerve possesses an extremely obscure sensibility, but which may, nevertheless, become very acute in pathological states. It conveys to organs the unconscious, motor excitations originating in the spinal cord or its ganglia; and through the filaments it furnishes to the vessels—the vaso-motor nerves—it holds under its control the circulatory phenomena, especially in the capillary plexuses, causing these canals to suddenly dilate or contract, and thus diminish or accelerate the flow of blood in them. By this action on the blood-vessels, it may have a secondary influence on the nutrition of the organs to which these vessels are distributed.[1]

[1] Francois Franck has published, in the *Travaux du laboratoire de M. Marey, pour l'Année* 1875, a long memoir on the "Nerfs Vasculaires de la tête." The author passes in review the

Differential Characters in the Great Sympathetic of the other Animals.

In all the domesticated Mammals, the general disposition of the great sympathetic is very similar; so that there are but few and slight differences to note.

In the **Ox**, the cervical filament of the sympathetic does not arise from the lower extremity of the superior ganglion, but behind, from its middle portion; it is divisible into two or three filaments for a certain distance, after which it lies beside the pneumogastric. The ramuscule that leaves the lower end of the cervical ganglion is very large, and reaches the division of the common carotid; that which accompanies the internal carotid artery is also of considerable size. (Ruminants have 13 thoracic and 6 lumbar ganglia.)

In the **Dog**, the cervical sympathetic cord is closely united with the pneumogastric, and it is not possible to separate them from each other, as can be done in Solipeds and Ruminants. (In the Carnivora, there are 13 thoracic and 7 lumbar ganglia.)

In the **Rabbit**, there are two cords which are independent along the whole length of the neck.

The **Pig** has a superior cervical ganglion, which is fusiform and very long; at its lower extremity it gives off several filaments, one of which lies beside the pneumogastric in the cervical region, but separates from it to join the middle cervical ganglion; the others pass to the tenth nerve, and are confounded with it at the ganglionic enlargement it shows behind the pharynx. At the entrance to the chest, a branch separates from the pneumogastric, passes along with the axillary arteries, and finally enters the heart. This branch is perhaps formed by the filaments of the sympathetic that joined the pneumogastric at the upper part of the neck. (The inferior cervical ganglion, according to Leyh, is completely isolated from the thoracic ganglion. The Pig has 14 thoracic and 7 lumbar ganglia.)

In the other domestic animals other than Solipeds, the number of ganglia in the dorsal, lumbar, and sacral portions depends upon the number of vertebræ in these several regions in the different species. In them, the first subdorsal ganglion is more voluminous and detached than in the Horse.

Comparison of the Great Sympathetic in Man with that of Animals.

It is divided and disposed as in animals. The *cervical portion* is composed of a superior fusiform ganglion, from which emerge many branches that have been studied with the greatest care. There are described: 1. Superior or intercranial branches. 2. External or anastomosing branches with the first four spinal nerves. 3. Internal or visceral branches, which mix with the pharyngeal and laryngeal filaments of the pneumogastric. 4. Anterior or external carotideal branches, which pass to the common carotid and the middle of a small ganglion, the intercarotid. 5. Posterior, muscular, or osseous branches. All these are present in the Horse. A cervical filament and two inferior ganglia—middle and inferior—complete this region, of which there is nothing more to be said.

The *thoracic portion* is absolutely identical in its disposition with that of animals; it gives rise to a great splanchnic nerve, and terminates in the semilunar ganglia.

There are no differences to note in the *lumbar* and *sacral portions*, which we have described as the pelvic.

CHAPTER IV.

THE NERVOUS SYSTEM IN BIRDS.

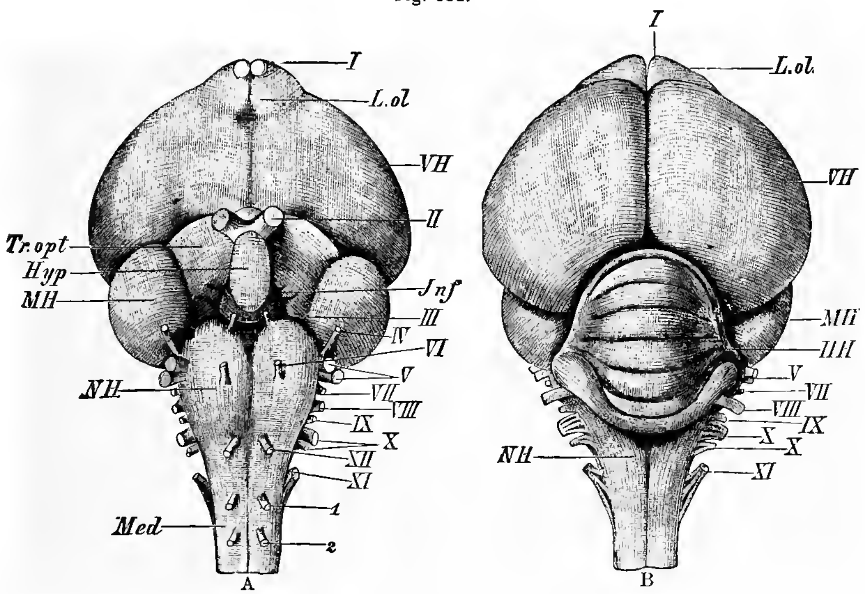
Protective Parts of the Cerebro-spinal Axis.—The protective parts of the nerve-centres are the same in all vertebrate animals; consequently, there

works of his predecessors, and makes known the new results he has obtained in associating anatomy with physiology, summing them up in the following principal conclusions: 1. The vessels receive their nerves from the free filaments of the sympathetic, and from filaments of the same kind contained in the mixed spinal nerves obtained by the latter from the spinal cord and the ganglia. 2. The superficial and deep vessels of the face are innervated by the free sympathetic filaments from the superior cervical ganglion and the pre-vertebral cord, and by the branches of the facial and the trigeminus. 3. The vessels of the ear receive their nerves from the free sympathetic, the facial, and the trigeminus, as well as the cervical plexus. 4. The encephalic vessels are innervated by the carotid and vertebral plexuses.

is nothing to remark regarding those of Birds, beyond what has been said at p. 158. The *envelopes* or *meninges* are three in number, and disposed as in Mammals.

"The *falx cerebri* is found in Birds; in the **Turkey** it has the form of the segment of a circle, and extends from the middle of the interval of the openings for the olfactory nerves to the tentorium cerebelli. The *falx cerebelli* is absent; the *tentorium* is small and sustained by a bony plate, and there are, in addition, two particular folds, one on each side, that separate the hemispheres from the tubercula quadrigemina" (Cuvier). Owing to the absence of the falx cerebelli,

Fig. 481.



BRAIN OF A BIRD. A, INFERIOR FACE; B, SUPERIOR FACE.

NH, Medulla oblóngata; *Med*, spinal cord; *HH*, cerebellum; *MH*, optic lobe; *VH*, cerebral hemisphere; *L.ol*, olfactory lobe; *Hyp*, hyopophysis. *Tr. opt*, optic tract; *I*, olfactory nerves. The cranial nerves are indicated by the corresponding numerals.

the meninges of Birds are closer together than those of Solipeds or Man. According to Leydig, the falx cerebri is partially ossified in birds.

SPINAL CORD.—In Birds, the spinal cord is perforated by a central canal, and also offers, as in Mammals, two enlargements—a cervico-dorsal and lumbar. It is prolonged into the coccygeal vertebræ, and thus furnishes another proof against the assertion of certain naturalists, who desire to establish a relation between the length of the spinal cord posteriorly, and the development of the coccygeal region. The two fasciculi of the medullary axis are separated from one another at the lumbar enlargement, and afterwards join in the sacral region. Between them is an elliptical space—the *rhomboidal sinus*—which is filled by transparent gelatinous connective substance—a kind of efflorescence of the ependymis of the central canal.

ENCEPHALON.—In a medium-sized **Fowl**, the brain weighs about $2\frac{1}{2}$ drams, and comprises the three portions present in Mammalia.

The *encephalic isthmus* is not divided into two sections by the pons Varolii, which is absent in birds; the crura cerebelli are immediately connected with the corpora restiformia. The lower face of the isthmus is very convex posteriorly; in front, the tubercula bigemina are united to each other by a comparatively large transverse cord, formed by the optic nerves intercrossing in the median line. The superior face is depressed above the cerebellum, so as to constitute a fourth ventricle, the floor of which is also shaped like the point of a pen; in front of this ventricle are the tubercula bigemina (*optic lobes*)—two voluminous tubercules separated from each other above, where they embrace the cerebellum, and salient on the sides of the lower face. They are hollow internally, and communicate with the aqueduct of Sylvius. The thalami optici are little developed.

The *cerebellum* is almost reduced to the median lobe, the lateral lobes—situated behind and below it—being very small and conical. By its anterior extremity, this cerebral ganglion passes between the corpora bigemini, and touches the cerebral hemispheres. The cerebellum is annulated transversely to its surface, and between the principal furrows are secondary ones, as in Mammals. The white substance forms, in its interior, an arborization in relation, by the number of its branches, with the simplicity observed on the surface of the organ. In the centre of the cerebellum of birds is a small cavity communicating with the fourth ventricle.

The *cerebrum*, divided into two hemispheres by a shallow fissure, has the shape of the heart on a playing-card, more particularly when viewed on its lower face. The convolutions are absent on the upper and lateral faces of the organ, and on the inferior is a vestige of the fissure of Sylvius, which is directed obliquely forward and outward. The olfactory lobes are little developed, and are placed together in the mesian line.

The two ventricles are confounded, there being no corpus callosum nor septum lucidum. There is no reflected portion in the ventricle; consequently the hippocampi and mastoid lobules are absent; the corpora striata are, on the contrary, large, and occupy nearly the whole floor of the ventricles.

Cranial Nerves.—These are twelve pairs, as in Mammals; and their origin is analogous, if not identical; the only trifling differences observed are due to the absence of the pons Varolii, and the convexity of the lower face of the isthmus.

Olfactory nerve.—We have mentioned above how this is formed at the anterior portion of the cerebral hemispheres.

Optic nerve.—It appears to be detached from the tubercula bigemini, and, after a very short course, to intercross with that of the opposite side. In certain Birds, and especially in the diurnal rapacious kind, the optic nerves are constituted by fasciculi of undulating nerve-tubes.

Common motores oculorum. Pathetici. External motores oculorum.—There is nothing particular to remark respecting these.

Trigeminal nerve.—This nerve divides into three principal branches, as in the domesticated animals. The *ophthalmic branch* has a nasal ramuscule that becomes superficial, and extends to the extremity of the beak, as well as a third filament that is lost around the inferior orifice of the nasal cavities.

The *superior maxillary* issues from the cranium by the opening through which the lower maxillary nerve passes, creeps below the orbit, traverses the maxillary bone, and terminates on the sides of the beak by filaments that resemble the infra-orbital ramuscules of the Horse.

The *inferior maxillary* furnishes two branches : one passes through the dental canal, and arrives at the extremity of the lower mandible ; the other is spread in the subcorneus integuments of the same.

Facial nerve.—This is small in Birds. "It is distributed to the muscles of the jaws and the small muscles which erect the feathers of the crest" (Cuvier).

Glosso-pharyngeal nerve.—This calls for no remark.

Pneumogastric nerve.—There are few differences observed in this; it is as extensive as in Mammals, and its anastomoses and relations are nearly the same. It is not entirely formed at its exit from the cranium, and always offers two or three constituent filaments that join it, and are confounded at some distance from the point of emergence. The recurrents furnish ramuscules to the crop.

Spinal accessory nerve.—This likewise has a medullary root that appears at the third cervical vertebra; it runs along with the vagus nerve to become superficial.

Hypoglossal nerve.—The same origin as in Quadrupeds. Where it crosses the pneumogastric, it detaches a long filament that passes along with the jugular vein towards the chest. On the sides of the larynx it bifurcates; one branch proceeds forward beneath the tongue, the other follows in the same direction, but on the upper surface of that organ.

SPINAL NERVES.—We need only notice the nerves of the wing and pelvic limb, the others being disposed in a similar manner to those above described.

Brachial plexus.—Three principal branches—the last cervical and first two dorsal—form this plexus in **Palmipeds**; in the **Gallinaceæ** there are four—the last three cervical and first dorsal. These branches anastomose beneath the deep face of the scapulo-humeral articulation. When fully constituted, the plexus gives off some collateral ramuscules, and terminates by two fasciculi of branches. The first collateral goes to the deep pectoral muscle; another is distributed to the muscles surrounding the head of the humerus, as well as to the articular capsule. The fasciculi of terminal branches may be distinguished, after their situation, as anterior and posterior. The latter represents the *internal brachial*, *cutaneous*, and *radial nerves*; it gives off muscular and cutaneous ramuscules that extend to the digits at the extremity of the wing. The anterior fasciculus is larger, and is also extended to the whole of the limb, being expended in motor and sensitive filaments; near its origin it furnishes ramuscules to the superficial pectoral muscle. This fasciculus represents the *median*, *ulnar*, and *anterior brachial*, or musculo-cutaneous of Mammals.

Lumbo-sacral plexus.—Two lumbar and four sacral nerves constitute this plexus. In the **Fowl** it is distinctly divisible into two portions, an anterior and posterior, considerably wide apart.

The *anterior portion* is composed of the lumbar branches and a portion of the first sacral; their fusion takes place on the salient bony ridge that separates the lumbar from the sacral regions. It gives origin to four or five branches, among which are clearly discernible : 1. A *filament to the tensor fascia lata muscle.* 2. A *crural* or *femoral nerve.* 3. An *internal saphenic nerve* that descends to the leg. 4. An *obturator nerve.* The latter is very slender, and directed downwards and backwards, passing into the muscle that closes the obturator foramen.

The *posterior portion* comprises a portion of the first sacral, and the whole of the three succeeding nerves. These are directed outwards, towards the sciatic notch, where they unite; during their course in the interior of the pelvis, they are surrounded by the tissue of the kidney. The distribution of this portion of the plexus resembles that of the Horse. Thus, in leaving the great sciatic notch, it gives off the *anterior* and *posterior gluteal nerves*, then two long branches that lie together as far as the gemelli. These branches are: 1. The *great sciatic*, with a ramuscnle for the gemelli and the posterior tibial muscles. 2. The *external popliteal*, which, outside the superior extremity of the leg, divides into the *musculo-cutaneous* and *anterior tibial nerve*.

BOOK VII.

THE SENSORY APPARATUSES.

Among the nerves described in the preceding book, those which have been designated *sensory nerves* have for their principal, or even exclusive function, the transmission to the brain of the impressions derived from the surrounding physical world. These nerves are, therefore, the essential instruments of sensation, and the organs to which they are distributed constitute the **sensory apparatuses.** These are admirably disposed for the reception of the cerebral stimuli, and are five in number—the *apparatuses of touch*, *taste*, *smell*, *vision*, and *hearing*. The principal characteristics of these will be briefly enumerated.

CHAPTER I.

APPARATUS OF TOUCH.

The sense of touch is destined for the appreciation of tactile sensations, and, incidentally, those resulting from variations of temperature. The apparatus which ministers to it, is formed by the peripheral radicles of the nerves of general sensibility distributed in the skin—the resisting membrane closely investing the entire body, and continuous, at the margin of the natural openings, with the mucous or internal membrane.

The entire skin, therefore, represents the organ of touch; but, as in Man, this membrane has certain privileged regions which are more active than others in the exercise of this faculty—these are the limbs and the lips.

The structure of the skin, though pertaining to general anatomy, will be studied here somewhat in detail, and then the arrangement of its appendages—the hair and horny productions—will be examined.

Article I.—The Skin.

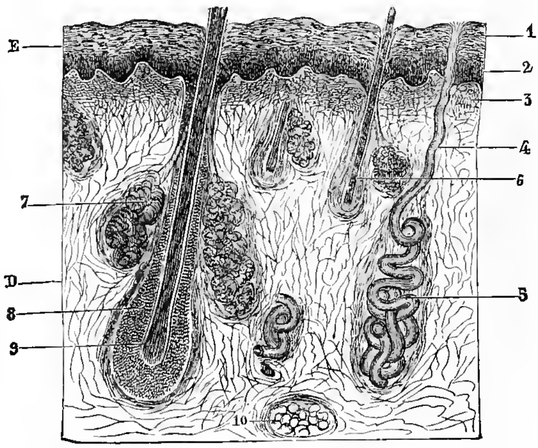
Preparation.—See treatises on histology.

The skin, properly speaking, is composed of two layers: the *derma* and *epidermis*.

The Derma.—The *derma* or *corium* (*corium cutis*, *cutis vera*), forms nearly the entire thickness of the membrane. Its inner face (*stratum subcutaneum*) adheres more or less closely to the subjacent parts, through the medium of a cellulo-adipose expansion (*panniculus adiposus*). Its external face, covered by the epidermis, is perforated by openings through which the hairs pass, or through which the secretion of the sudoriparous and sebaceous glands is thrown out upon the surface of the skin; this external face also shows a multitude of little elevations termed *papillæ*, in which the majority of the nerves terminate.

The derma is not of the same thickness everywhere, being much thinner where it is protected from external injury—as on the under-surface of the belly, the inner side of the legs, thighs, etc.; it is also thin around the margin of the

Fig. 482.



SECTION OF HORSE'S SKIN (FROM WING OF THE NOSTRIL).

E, Epidermis; D, derma. 1, Horny layer of the epidermis; 2, stratum mucosum; 3, papillary layer of the derma; 4, excretory duct of a sudoriparous gland; 5, glomerule of a sudoriparous gland; 6, hair-follicle; 7, sebaceous gland; 8, internal sheath of the hair-follicle; 9, bulb of the hair; 10, mass of adipose tissue.

natural openings, to permit the transition between the two membranes, and to endow these apertures with their necessary dilatability.

Structure.—The derma is composed of fasciculi of connective tissue interwoven and matted in a solid manner, and in the meshes of which are some smooth muscular fibres, which, by their contraction, produce the condition of the skin known as the *cutis anserina* (*goose-skin*). Somewhat loosely woven in its deepest part to form the *reticular layer* (*stratum reticulare*), the derma contains the roots of the hair-follicles, the sudoriparous (or *sweat*) glands, and small masses of adipose tissue; superior, its structure is very condensed, to constitute the *papillary layer* (*stratum papillare*), the superficial limit of which forms an amorphous layer (*basal membrane*).

Fig. 483.

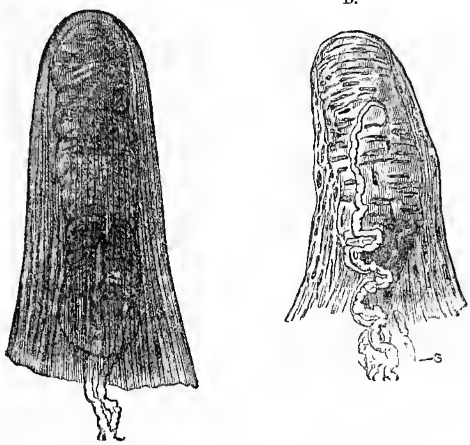
CAPILLARY LOOPS IN THE CUTANEOUS PAPILLÆ OF THE LIPS.

The *papillæ* are of two kinds—vascular and nervous, and are regularly arranged in parallel series. They are most numerous in those parts of the skin especially destined for the exercise of touch—as at the lips, in the keratogenous membrane (of the foot), and other parts where sensibility is very acute—such as the scrotum, sheath, and integuments of the penis. The papillary prolongations of the derma are conical or fungiform, and pediculated; their dimensions are very variable; measuring from $\frac{1}{118}$ to $\frac{1}{276}$ of an inch in length, and from $\frac{1}{118}$ to $\frac{1}{984}$ of an inch in width at their base. The nerve-papillæ are the organs of touch, and contain either the *corpuscula tactûs* (or *axile bodies*) of Meissner or those of Kraüse.

The *sebaceous glands* lie beside the hair-follicles, each hair being flanked by two glands. These small organs are composed of a very granular epithelium, and are usually oval in shape. (They are embedded in the upper stratum of the derma, and present every degree of complexity—from the simplest follicle to the compound lobulated gland. In some situations, their excretory ducts open independently on the surface of the epidermis. Those associated with the hairs are raceiform and lobulated, consisting of glandular vesicles, which open by short pedunculated tubuli into a common excretory duct, and the latter, after a short course, into the hair-follicle. In some parts the ducts are short and straight; in others, where the skin is thick, they are spiral. They are lined by an inversion of the epidermis, which forms a thick and funnel-shaped cone at its commencement, but soon becomes soft and uniform. Sebaceous glands are met with in all parts of the body, but are most abundant in those parts which are naturally exposed to the influence of friction, or require to be supple. The sebaceous glands of large hairs are appendages of the follicles; but where there are soft woolly hairs, they are rather appendages of the glands. The secretion—*sebum*—is a fatty matter mixed with the *débris* of broken-down cells. The glands are very large and numerous in the sheath—*preputium penis*, where they are designated *Tyson's glands*. Müller found in the Pig a special cutaneous gland, somewhat resembling the sebaceous glands. It is situated on the inner and posterior aspect of the knee, and is from $\frac{3}{4}$ to 2 inches in length, and from $\frac{1}{4}$ to $\frac{1}{2}$ inch in width. In the Sheep, there is found, in the skin between the claws, a particular inversion of the integument that forms a small elongated pouch, curving upwards, and terminating in a *cul-de-sac*. This is the *interdigital pouch, interungulate gland, sinus*, or *biflex canal*—*sinus cutaneus ungularum*; it secretes a viscid matter from glands which, according to Ercolani, are analogous to the sebaceous glands. The pouch is lined with very fine hairs, and often contains foreign substances, such as sand; it sometimes becomes inflamed and its orifice occluded, when it is transformed into a retention cyst.)

Fig. 484.

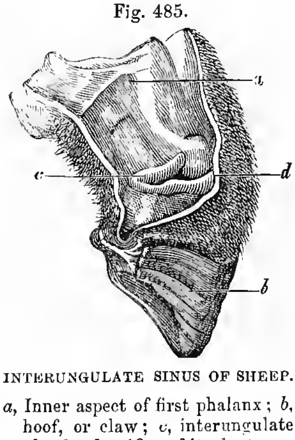
A. B.



TACTILE PAPILLÆ FROM THE SKIN, SHOWING THE *tactile corpuscles*, OR "AXILE BODIES."

A, In the natural state; B, treated with acetic acid.

Fig. 485.

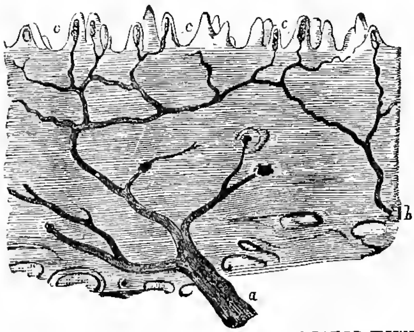


INTERUNGULATE SINUS OF SHEEP.

a, Inner aspect of first phalanx; *b*, hoof, or claw; *c*, interungulate gland; *d*, orifice of its duct.

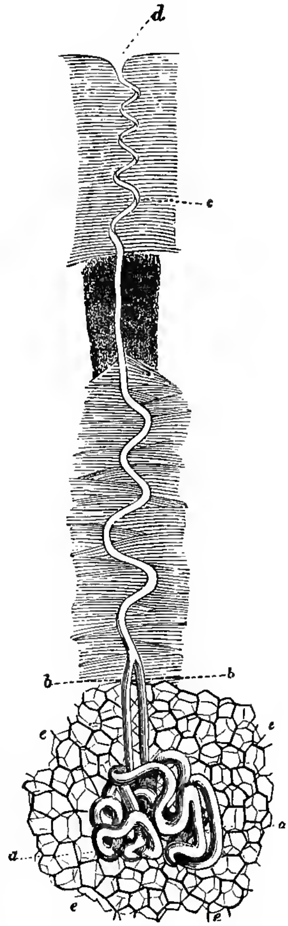
The *sudoriparous glands* are deeper situated than the last (passing even into the subcutaneous connective tissue, where they are surrounded by adipose cells). They consist of a convoluted tube (or several tubuli produced by dichotomous subdivision) embedded in the reticular layer of the derma, and form an elliptical glomerule, generally lying obliquely to the surface of the skin in the Horse. The

Fig. 486.



VERTICAL SECTION OF THE SKIN TREATED WITH A SOLUTION OF CAUSTIC SODA, showing the branches of cutaneous nerves, *a*, *b*, inosculating to form a terminal plexus, of which the ultimate ramifications pass into the papillæ, *c*, *c*, *c*.

Fig. 487.



SUDORIPAROUS GLAND (MAGNIFIED 40 DIAMETERS).

a, *a*, Contorted tubes composing the gland, and uniting in two excretory ducts, *b*, *b*, which join into one spiral canal that perforates the epidermis at *c*, and opens on its surface at *d*; the gland is embedded in fat vesicles, *e*, *e*.

excretory canal is a continuation of this glomerule, and passes through the derma and epidermis in a spiral manner. (The tube is lined with a single layer of cubical cells containing pigment and fat-granules, while its wall is formed of a delicate *membrana propria*. In large glands, smooth muscular fibres are found between the *membrane propria* and the gland cells.)

The *blood-vessels* form a very rich network in the papillary layer of the derma, and also surround the sebaceous and sudoriparous glands. The *lymphatics* are disposed like the capillaries.

(The *arteries* arise from vessels in the underlying fasciæ, and pass vertically towards the surface, forming three sets of capillaries—the deepest to the adipose tissue, the next run round the sweat-glands, the last—the terminals—form a net-work in the *stratum papillare*, which sends loops into the papillæ and small twigs into the hair-follicles and sebaceous glands. The *veins* arise in the *stratum papillare* from the loops in the papillæ, and from the follicles and sebaceous glands.

The *lymphatics* form two capillary networks —one of fine vessels forming narrow meshes in the *stratum papillare*, below the blood-capillary network; and one with wider meshes, in the subcutaneous tissue. Minute lymphatics are also found outside the hair-follicles and the two sets of glands.)

The *nerves* are arranged in two layers: one loosely distributed in the derma;

the other very close, and lodged in the papillary layer, which is traversed by recurrent fibres giving off tubes that pass into the nerve-corpuscles of the papillæ.

The superficial network detaches the terminal fibres that pass into these papillæ or into the *stratum mucosum* of the epidermis. The intra-epidermic nerve terminations have been particularly observed in the snout of the Pig.

EPIDERMIS.—The *epidermis* is a thin pellicle, covering the superficial face of the derma; it is destitute of blood-vessels, and is formed of cells which are being continually deposited on the derma; these cells become flattened in layers as they are pushed up from the latter, and are destroyed by friction on the surface of the skin. The deep face of the epidermis is moulded on the upper surface of the derma; consequently, it lodges the papillæ, and dips into the follicles and excretory ducts of the glands of the skin; its external face is not a very exact repetition of the surface of the derma, and is covered with hair. The epidermis tends to equalize, and to fill up, the depressions existing between the papillæ.

Structure.—The epidermis comprises two layers, which are not very distinct from each other in the Horse. The *deep layer*, or *rete Malpighi* (*stratum mucosum*), is composed of soft, nucleated, pigmented, denticulated cells, which are sometimes attached by their fine prolongations (*prickle-cells*) to other cells more or less distant; there are spaces between them filled with an amorphous semifluid substance. The *superficial* or *horny layer* (*stratum corneum*), is constituted by hard, horny, flattened cells, which still contain some pigment-granules, and are insensibly confounded with those of the rete mucosum.

Fig. 488.

OBLIQUE SECTION OF EPIDERMIS, SHOWING THE PROGRESSIVE DEVELOPMENT OF ITS COMPONENT CELLS.

a, Nuclei resting upon the surface of the derma, *f*; these nuclei are gradually developed into cells at *b*, *c*, and *d*, and the cells are flattened into lamellæ, forming the outer surface of the epidermis, *e*.

(Where the epidermis is thick, there is seen between the two layers just mentioned, a third—the *stratum lucidum*—the nature of which has not yet been defined. It is transparent, and apparently amorphous. The theory of growth of the epidermis is believed to be as follows: a layer of plastic lymph is thrown out on the surface of the derma, and is converted into granules, which are termed *cell-germs*, or *cytoblasts*. These imbibe serum from the lymph and adjacent tissues, so that the outermost covering of the cytoblast is gradually distended; the latter becomes a cell, and its solid portion, which always remains adherent to some point of the inner surface of the cell membrane, forms the nucleus of the cell. Within this nucleus one or more nuclei are developed; these are named *nucleoli*. The process of imbibition continuing, the cell becomes more or less spherical; so that, after a certain time, the papillary layer of the derma is covered by a thin stratum of spherical cells pressed closely together, and corresponding with every irregularity of the papillæ. New cells being continually produced before the formation of the others has been quite completed, these are removed in layers further and further from the surface of the derma, and, becoming subjected to the influence of physical laws, their fluid contents evaporate; they collapse, flatten, and gradually assume an elliptical shape; then they are a mass of completely flat cells, with an included nucleolated nucleus, and finally become a thin membranous scale, in which the nucleus is scarcely apparent.)

In Solipeds and other animals, the epidermis is generally dark-coloured, from the presence of pigment-corpuscles, the number of which increases with their depth in the membrane. This coloration is perhaps intended to prevent the rubefacient effects of the heat of the sun's rays, by augmenting the absorbing and dispersing power of the cutaneous surface. In the majority of cases, this coloration is absent in the Sheep, whose skin is protected by a thick fleece; and also in the Pig, whose habits in a wild, as in a domesticated condition, keep it out of the direct action of the sun.

(In some regions of the body of all animals, the skin forms folds, as at the junction of the fore limb with the body, the flank, and between the thighs. In the Cow, it forms the large pendulous layer at the throat and breast, known as the "dewlap;" and in the Goat and Pig, it not unfrequently constitutes teat-like prolongations depending from the throat, which nearly always contain a small cartilaginous nucleus and some muscular fasciculi. The thickness of the epidermis is sometimes greatly increased by wear and friction, as we frequently see in the skin covering the knees of Sheep, etc.)

(The functions of the skin are, as we have seen, tactile and secretory; in addition, it is eminently protective. Its secretory action is always more or less active, but the production of perspiration is greatest when the body is at a high temperature, as during active exertion; at other times the perspiration is *insensible*. In this respect, the skin has intimate sympathetic relations with other organs which have somewhat analogous functions, such as the lungs, kidneys, intestines, etc., and when its function is disordered or checked, it induces alterations in the secretions of one or all of these organs. The skin is also the seat of a constant and important respiratory action, as it absorbs oxygen and throws off carbonic acid, and any interruption to this process is injurious.)

The skin of Ruminants shows, at certain points, depressions destitute of hair, but extremely rich in sebaceous glands. Such is the *tear fossa* situated on the face, and the *biflex canal* between the digits—as in the *Sheep*, and particularly in the *Goat*. (It should be remarked that *sweat-glands* are found in the skin of the *Ox*, and in the pads of the feet of *Dogs* and *Cats*. They attain a great size in the pig's snout. The nose and upper lip of Ruminants, and that of the *Dog* and *Cat*, contain racemose glands that secrete a clear, watery, alkaline fluid.)

Article II.—Appendages of the Skin.

Preparation.—See treatises on histology.

The appendages of the skin are *hairs* and *horny productions*, dependencies of the epidermic layer.

Hairs.

The *hairs* are the filaments which, collectively, form the external covering of the skins of animals.

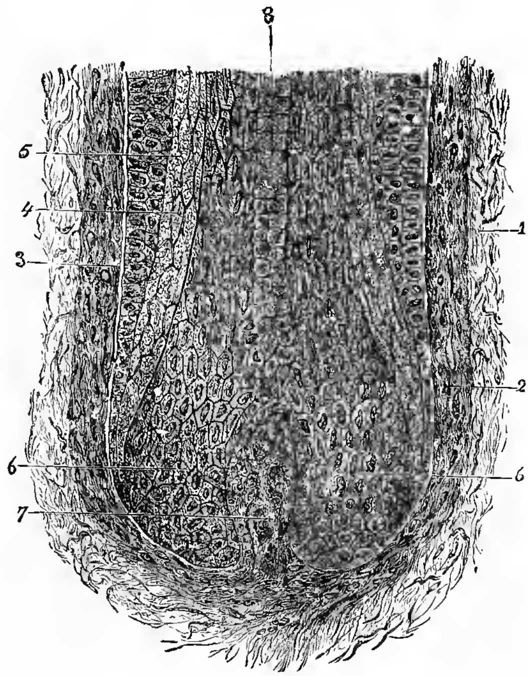
In the Horse, the bristly appendages known as *horsehair* should be distinguished from the *hairs proper*; the latter are fine and short—particularly in the regions where the skin is thin—imbricated on each other, and spread over the entire surface of the body in a continuous layer which is designated the *coat*. The former are long and flowing, occupy the summit of the head, where they constitute the *forelock*; the upper border of the neck, where they form the *mane*; and cover the caudal appendage with a splendid tuft—the *tail*. Some of these also form special organs on the free margin of the eyelids, and are termed *eyelashes*; while others, inserted about the lips and below the eyes, are named *tentacula*. (The eyelashes are chiefly implanted in the upper lid.

The hairs of the tail are the longest and strongest in the body. These particular hairs also grow on the posterior aspect of the limbs, generally from about the knees and hocks to the hoofs; at the sesamoid bones they constitute a long tuft—the *fetlock*—which surrounds the horny growth named the "ergot." These "foot-locks" are peculiar to the Horse, and vary in length and coarseness with the breed of the animal.)

When the hair is fine, long, and wavy, it forms *wool;* and when straight and rigid, as in the Pig, it is known as *bristles.*

In the **Ass** and **Mule,** the forelock and mane are rudimentary or absent, and the hair of the tail is limited to a small tuft at the extremity of the organ in the former animal; while in the latter it is much less abundant than in the Horse.

Fig. 489.



HAIR-FOLLICLE.

1, External dermic layer of the follicle; 2, internal dermic layer; 3, amorphous lining of the follicle; 4, external epidermic layer; 6, hair-bulb; 7, vascular papilla; 8, cells of the medullary substance.

In the **Ox,** these hairs are not present, except at the extremity of the tail, as with the Ass.

There are no other animals which have other hair than that composing the coat.

(The ordinary hair of the coat is soft and elastic, inclined in particular directions, and varies in length not only according to the regions of the body on which it grows, but also according to the season or climate. In the Horse, the direction of the hair of the coat gives rise to curiously formed waves, lines, and circles, the most constant of which is on the forehead.

In the **Cow,** the hair is frizzly on the forehead; on the posterior part of the thighs it has a particular direction, while on the outer side it passes downwards, and from the posterior part of the mammæ it ascends as high as the vulva; this characteristic disposition forms what the French have termed *écussons,* by which some have pretended to recognize the lactiferous qualities of the animal.

In the **Sheep,** real hair—not wool—is found on the lower part of the face, and the extremities of the limbs.

In the **Goat,** the hairs of the beard are very long, and compose a distinctive tuft; this animal has also a fine crisp *duvet* or *down* beneath the ordinary hair.

In the **Pig,** the bristles are very strong in the region of the back; in old animals they are usually bi- or trifurcated at their free extremity; there also exists a fine soft hair on this animal. It has no tentacular hairs.

In the **Dog**, the length, fineness, and consistency of the hair depends on the breed.

In the **Cat**, the hair in some breeds—as in the Angora—is remarkable for its length and softness. This creature has the tentacula enormously developed as a moustache.

In none of these animals is there a "foot-lock.")

STRUCTURE.—The hairs are implanted in the texture of the derma, and sometimes even in the subjacent tissues, their base being enclosed in a follicle, at the bottom of which their elements are developed. It is therefore necessary to study: 1. The structure of the hair. 2. That of the hair-follicle.

1. The *hair* presents a free portion—the *shaft* (*scapus*), and another concealed in the follicle—the *root* (*radix pili*); the latter widens at its base—the *bulb* (*bulbus pili*) of the hair—to embrace the *papilla* or *hair-germ.*

There are three superposed layers in a hair. The *epidermis* (*cuticle*) is a thin lamella of horny flattened cells, imbricated like tiles on a roof. Its elements are marked on the surface of the hair by shaded lines anastomosing to form a network; they enlarge, and become more apparent under the influence of an alkali. The epidermis belongs to the shaft and a portion of the root; near the bulb it is replaced by soft nucleated cells, which are implanted vertically.

The *cortical substance* (*cortex*) forms the largest part of the thickness of the hair. It is striped longitudinally, and provided with pigment granules, the number of which varies with the colour of the coat. In white hairs these granules are absent, but there are found in them, as well as in coloured hairs, small spaces containing air, and which exhibit a dark colour under the microscope. Treated by potassium or sulphuric acid, the cortical substance is reduced to elongated spindles, which again may be decomposed into slender epithelial lamellæ without nuclei. On arriving at the root, the cells change their character, becoming polyhedric, filled with fluid, and exhibit a perfectly distinct nucleus and more or less pigment. The *medullary substance* (*medulla*) occupies a narrow irregular cavity in the centre of the hair, extending from the bulb or termination of the root, to the point. It has for its base rectangular, rarely circular, cells, which, according to Kölliker, contain fat-granules and air-globules. (Many hairs show no medulla, and even in thick hairs it does not always extend the entire length of the hair.)

2. The *hair-follicle* is a narrow cavity, slightly contracted at its orifice and dilated at the bottom, where the hair-papilla is placed. It is a simple involution of the skin, as its structure demonstrates. It presents, from without to within: 1. A loose conjunctival layer, analogous to the reticular layer of the derma. 2. An internal dermic layer, dense and close like the papillary layer of the skin. 3. An amorphous limiting membrane. 4. An epidermic zone—the *external sheath of the hair*—formed by cells, similar to those of the stratum mucosum. 5. A second epidermic zone—the *internal sheath of the hair*—which repeats the horny layer of the epidermis, and is confounded with the termination of the epidermis of the hair towards the lower third of the follicle.

The *papilla*, or *hair-germ*, is a small, conical, vascular, and nervous prolongation rising up into the hair-bulb. It furnishes the hair with nutrition and the elements of growth.

The walls of the follicles of the enormous hairs—or *tentacula*—which garnish the lips of the Horse, or bristle from those of the Cat (*moustaches*), are provided with nerve-ramifications which endow these appendages with a high degree of sensibility, and enable them to play an important part as organs of touch.

The follicles of these large hairs show, between the second and third layers of their wall, a vascular dilatation—a kind of erectile tissue—that probably plays a part also in the exercise of touch (Leydig, Odenins, Paladino, etc.).

Two *sebaceous glands*, and a *smooth muscular fasciculus*, are annexed to the pilous follicle. The sebaceous glands—which have been already described—open into the sheath of the hair by a small excretory canal, which traverses the fibrillar walls of the follicle. The muscular fasciculus (*musculus arrector pili*) is situated on the side to which the hair and its follicle are inclined; it arises from the superficial face of the derma, and terminates at the bottom of the follicle, which it erects by contracting. When the fasciculi contract over a wide surface, the extent of the skin is diminished, and the hairs are erected and partially ejected from their follicles—producing the *cutis anserina*.

(Next to the innermost layer of the corium of the hair is a layer of stratified epithelium—the *external root-sheath;* and lining this, in the upper part of the follicle, is the *internal root-sheath*, representing the stratum corneum. This inner root-sheath divides, near the orifices of the sebaceous glands, into two layers—*Henle's sheath* being the outer, and Huxley's sheath the inner.

The formation of a hair is identical with the formation of the epidermis by the papillary layer of the derma. The capillary plexus of the follicle throws out plastic lymph which is converted into granules, then into cells, which become elongated into fibres. The cells that are to form the surface of the hair, are converted into flat scales that enclose the fibrous structure of the interior. As these are successively produced, they overlap those previously formed, and give rise to the waving lines seen on the circumference of the hair; this overlapping also causes the roughness experienced in drawing a hair between the fingers from its point to the bulb. The latter is the newly formed part of the hair, its expanded form being due to the greater bulk of the fresh cells.

The colour of the hair is very varied in animals, ranging from black to white, red and brown, with all the intervening shades. The tint also changes at different periods of life, being sometimes altogether altered between the juvenile and adult periods; dark-coloured Horses becoming light-coloured as age advances. Besides, it is never uniform in the same animal; black Horses not unfrequently having white patches and diverse tints, with other dissimilarities. The disease termed "melanosis" is very common in old white Horses which were previously grey, and is supposed to be due to the localization of the black pigment at certain limited points. The hair grows according to the climate, seasons, food, etc., and varies with the species and breed. The *coat* in every animal is shed at certain times, and is replaced by new hairs.

The hair preserves the skin from unhealthy external influences—wet and cold for example. It is a bad conductor of heat, and therefore keeps the body warm. The tentacula are very useful as tactile organs; while the mane, forelock, and tail keep away insects, and the long hairs of the fetlock and pastern protect these parts from the injurious effects of cold and wet, and the action of foreign bodies.)

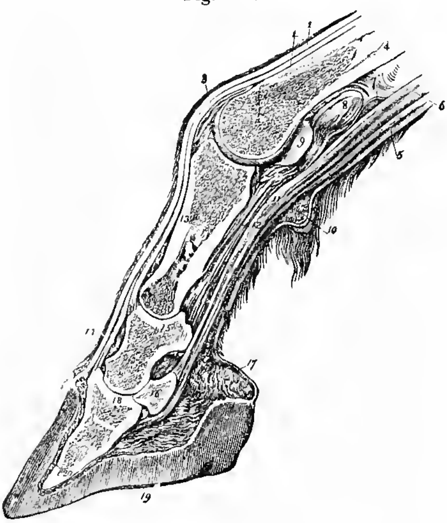
Horny Productions.

The horny tissues form several groups. The first comprises the *horns* of Ruminants; the second, the so-called *chestnuts* of Solipeds; the third, the protective layer enveloping the digital extremities, and constituting the *claws* of Carnivora, the Pig, Ox, Sheep, and Goat, and the *hoofs* of the Horse, Ass, and Mule. These latter productions, ranking as they do among the most important organs of the locomotory apparatus of Solipeds, will first receive notice.

1. The Hoof of Solipeds.

The *hoof* of Solipeds is an extremely important study, because of the numerous diseases which affect this region. Consequently, it has been the subject of several voluminous works, to which the student must be referred for a more complete description of its organization;[1] as we cannot do more here than give some essentially descriptive details, necessary to fill up the outline that we have traced out.

Fig. 490.



LONGITUDINAL MEDIAN SECTION OF THE FOOT.

1, Anterior extensor of the phalanges, or extensor pedis; 2, lateral extensor, or extensor suffraginis; 3, capsule of metacarpo-phalangeal articulation; 4, large metacarpal bone; 5, superficial flexor of the phalanges, or perforatus; 6, deep flexor, or perforans; 7, sheath; 8, bursa; 9, sesamoid bone; 10, ergot and fatty cushion of fetlock; 11, crucial ligament; 12, short sesamoid ligament; 13, first phalanx; 14, bursa; 15, second phalanx; 16, navicular bone; 17, plantar cushion; 18, third phalanx; 19, plantar surface of hoof; 20, sensitive or keratogenous membrane of third phalanx.

We will at first glance at the parts contained in the hoof, returning afterwards to a description of the horny case itself.

a. The Parts contained in the Hoof.

Proceeding from within to without, we find, in the interior of the horny box: 1. The third phalanx, navicular bone, and lower part of the second phalanx, forming the articulation of the foot. 2. The four ligaments that bind this articulation. 3. The tendon of the common extensor of the phalanges which covers the articulation in front, and that of the perforans which supports it behind, in becoming inserted into the pedal bone, after gliding over the posterior surface of the navicular bone. 4. The complementary apparatus of the third phalanx. 5. The matrix of the hoof, or keratogenous membrane—a continuation of the derma covering the digital region. To these parts must be added the vessels and nerves of this region.

The description of the bones has been given at pp. 114, 150;

Of the articulation and its ligaments, at p. 209;

Of the tendon of the anterior extensor of the phalanges, at p. 325;

Of the perforans tendon, at p. 331;

[1] See particularly, among the French works, the *Traité de l'Organisation du Pied du Cheval*, by M. H. Bouley. (See also the still more recent work by Leisering, *Der Futz des Pferdes* Dresden: 1870. Also a long series of papers by me on this subject in the *Veterinarian* for 1871–2.)

Of the arteries, at pp. 636, 654 ;
Of the veins, at pp. 698 to 703.
Of the nerves, at pp. 865, 881.

It remains to notice the *complementary apparatus of the third phalanx*, and the *keratogenous membrane*.

Preparation.—The dissection of the fibro-cartilages is made at the same time as that of the articulation of the foot. A good idea of the shape of the plantar cushion can be obtained in a longitudinal and median section of the digital region (Fig. 493), and on the piece prepared to show the subcorneal tissue. This is obtained by two procedures. In the first, we wait until decomposition has softened the cells between the hoof and the keratogenous membrane, when the hoof can be easily pulled off. In the second, the foot is kept for several hours in boiling water, then held in a vice by the pastern while the tissues around the coronet are slightly cut through; a pair of shoeing pincers is now employed at the heels in pulling the hoof up and down until it comes off. The foot is then washed to free it from the *débris*. (The hoof can also be removed by prolonged maceration, or by roasting on a fire, when it may be cut and torn off by the farrier's knife and pincers).

A. Complementary Apparatus of the Pedal Bone.—In the indication we gave of this apparatus at p. 117, it was mentioned that it was composed of two lateral pieces—the *fibro-cartilages* of the pedal bone, united behind and below by the *plantar cushion*—a fibrous, elastic mass, on which the navicular bone rests, through the medium of the perforans tendon. We will take this distinction as the basis of our study.

Fig. 491.

HORIZONTAL SECTION OF THE HORSE'S FOOT.

1, Front, or toe of the hoof; 2, thickness of the wall; 3, laminæ; 4, insertion of the extensor pedis; 5, os pedis; 6, navicular bone; 7, wings of the os pedis; 8, lateral cartilage; 9, flexor pedis tendon; 10, plantar cushion; 11, inflection of the wall, or "bar;" 12, horny frog.

1. Fibro-cartilages of the Pedal Bone.—Each of these pieces represents a plate flattened on both sides, having the form of an oblique-angled parallelogram, and prolonged behind the third phalanx. The *external face* is convex, and pierced with openings for the passage of veins; it slightly overhangs that of the pedal bone. The *internal face* is concave, channeled by vascular furrows, and covers, in front, the pedal articulation, and the synovial *cul-de-sac* that projects between the two lateral ligaments of that joint; below and behind, it is united to the plantar cushion, either through continuity of tissue, as at the inferior border, or by fibrous bands passing from one to the other. The *upper border*, sometimes convex, sometimes rectilinear, is thin and bevelled like a shell; it is separated from the posterior margin by an obtuse angle, in front of which this border is often broken by a deep notch that gives passage to the vessels and nerves of the digital portion. The *inferior border* is attached, in front, to the basilar and retrossal processes; behind the latter, it is reflected inwards to become continuous with the tissue on the lower face of the plantar cushion. The *posterior border* is oblique from before to behind, and above to below, and joins the preceding two. The *anterior border* is oblique in the same direction, and is united so intimately to the anterior lateral ligament of the pedal articulation, that it cannot be separated from it except by an artifice of dissection. It sends to this ligament, and to the tendon of the anterior extensor of the phalanges, a fibrous expansion that becomes fused with that of the opposite side.

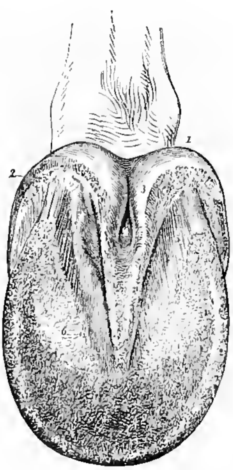
The fibro-cartilages comprise in their structure a mixture of fibrous and cartilaginous tissue, though the mixture of these is far from being perfectly homogeneous, or everywhere in the same proportions.

The cartilages of the fore feet are thicker and more extensive than those of the hind ones.

(The lateral fibro-cartilages are peculiar to Solipeds.)

2. **Plantar Cushion.**—The plantar cushion is a kind of wedge, situated in the space between the two cartilaginous plates of the third phalanx, and between the perforans tendon and the lower part of the hoof. Its shape allows it to be considered as having an *antero-superior* and an *infero-posterior face*, a *base*, *summit*, and two *lateral borders*.

Fig. 492.



LOWER FACE OF THE HORSE'S FOOT, THE HOOF HAVING BEEN REMOVED.

1, Heel; 2, coronary cushion; 3, branch of the plantar cushion; 4, median lacuna, or commissure; 5, laminæ of the bars; 6, velvety tissue of the sole.

The *antero-superior face* is moulded on the aponeurotic expansion of the perforans tendon, and is "covered by a cellulo-fibrous membrane, the *proper tunic of the plantar cushion*, which is continuous, on its inner face, with the fibrous septa by which this organ is traversed, and adheres by its external or anterior face to the reinforcing sheath interposed between it and the perforans tendon" (Bouley). This expansion is prolonged, above, to the fetlock, where it is confounded with the superficial fascia of the metacarpal region; it is margined, laterally, by two small, very strong ligamentous bands which, at their middle portion, cross in a very oblique manner the fasciculus formed by the vessels and nerves of the digit. Each of these bands is fixed, superiorly, to the base of the rudimentary digit known as the *ergot*, and to the knob of the lateral metacarpal bone; their inferior extremity is attached within the retrossal process.

The *infero-posterior face* of the cushion is covered by the keratogenous membrane, and presents at its middle the *pyramidal body*, a prominence exactly like that of the frog, to which it corresponds. It shows, then, in front, a single conical prolongation, and behind, two divergent prominences separated by a median excavation.

The *base* of the apparatus lies behind, and is inclined upwards; it is divided by a depression into two lateral masses—the *bulbs of the plantar cushion*—on the inside of which the posterior prominences of the pyramidal body reach, and which become confounded, outwardly, with the posterior and inferior angle of the cartilaginous plates. This portion of the cushion is, like the anterior face, covered by a cellulo-fibrous expansion, which separates it from the skin of the pastern; this expansion is attached, by its lateral margins, to the posterior border of the cartilages, and continued, superiorly, on the surface of the anterior expansion, with which it soon unites.

The *summit* (*point* or *apex*) forms a sharp border, more or less regularly convex; it is fixed into the plantar face of the pedal bone, in front of the semilunar ridge and the insertion of the perforans tendon, with which the plantar cushion mixes its fibres at this part.

The *lateral borders* are wider behind than before, in consequence of the wedge-like shape of the whole organ; they are continuous with the inner face of the lateral cartilages, as already indicated in describing the latter.

The *organization* of the plantar cushion differs much from that of the cartilages. It has for its base a fibrous structure, continuous with that which constitutes the fundamental framework of these; this structure is very dense towards the infero-posterior part of the organ, and becomes gradually looser as it leaves this region; the meshes it contains are filled with a yellow pulp composed of fine, elastic, and connective fibres, in the midst of which some adipose cells are found. (I have attentively examined this yellow pulp, and can perceive that it is essentially constituted by adipose tissue). Numerous blood-vessels and nerves complete this structure.

B. The Keratogenous or Subcorneous Membrane.—The keratogenous membrane envelops the extremity of the digit, by spreading over the terminal expansion of the tendon of the extensor pedis, through the medium of a fibrous fascia—a dependency of the lateral cartilages; and also over the inferior moiety of the external face of these cartilages, the bulbs of the plantar cushion, pyramidal body, anterior part of the plantar face of the third phalanx, and over the anterior surface of the same bone. It covers all these parts like a sock, and the hoof encloses it, as a shoe does the human foot.

This membrane becomes continuous with the skin of the digital region, at a circular line that intersects the middle portion of the second phalanx, and inclines obliquely downward from behind to before. Below this line, in front and laterally, the subungular tissues form a semi-cylindrical protuberance, covered with villi, and designated the "bourrelet." (This elastic prominence has received several most inappropriate names from English farriers and hippotomists, such as "coronary ligament," "coronary substance," "cutiduris," etc. From its function, structure, situation, and its analogy to the plantar cushion, I have designated it the "coronary cushion.")

On the plantar cushion and the lower face of the pedal bone, this membrane becomes a villous tunic—the *velvety tissue*—which is continuous, towards the bulbs, with the extremities of the coronary cushion.

The portion spread over the anterior face of the third phalanx constitutes the laminal (*podophyllous*) or "leafy tissue," so called because of the laminæ or parallel leaves seen on its surface.

The three regions of the keratogenous apparatus will be successively studied.

1. **Coronary Cushion.**—This part is the matrix of the wall of the hoof, and is lodged in a cavity excavated at the upper border of this part of the horny case. It forms, according to the expression employed by M. Bouley, a rounded prominence, which projects like a cornice above the podophyllous tissue.

Its *inferior border* is separated by a white zone from the upper extremity of the laminæ, which constitute this boundary.

The *superior border* is limited by a slightly projecting margin named the *perioplic ring*, because it secretes the horn of the periople. Between this margin and the cushion is a sharply defined groove.

The *extremities*, narrower than the middle portion, on arriving at the bulbs of the plantar cushion, bend downwards into the lateral lacunæ of the pyramidal body, where they become confounded with the velvety tissue.

The *surface* of the organ shows filiform prolongations, a little constricted at their base, and named *papillæ*, *villo-papillæ*, *villi*, and *villous loops*, the size of which is greatest towards the lower part of the cushion; those of the perioplic ring are smallest. Contained within the minute apertures at the upper part of the hoof-wall, these papillæ—considered as a whole, and when the hoof has been removed by maceration—form a tufty surface most perfectly seen when the foot is suspended in water.

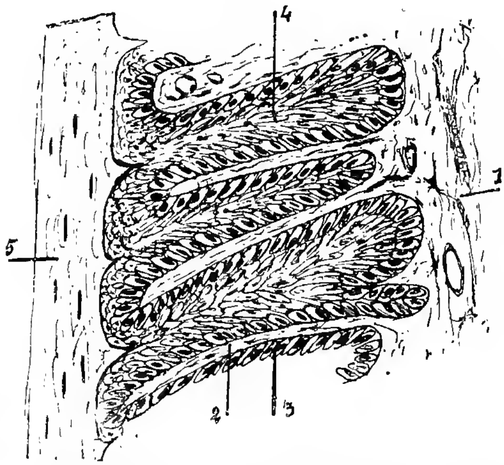
The structure of the coronary cushion resembles that of the derma, of which it is in reality only a continuation. It comprises a fibrous framework, remarkable for its thickness and density, with a considerable number of vessels and nerves, the ramifications of which may be followed to the extremity of the villi.

Fig. 493.

LATERAL VIEW OF THE HORSE'S FOOT, AFTER REMOVAL OF THE HOOF.

1, Perioplic ring, divided by a narrow groove from the coronary cushion, 2, which is continuous with the plantar cushion, 4, and joins the vascular laminæ, 3, through the medium of the white zone.

Fig. 494.



HIGHLY MAGNIFIED HORIZONTAL SECTION OF A HORSE'S HOOF, SHOWING THE RELATIONS BETWEEN A KERAPHYLLOUS AND A PODOPHYLLOUS LAMINA.

1, Principal podophyllous lamina; 2, secondary ditto (*laminella*); 3, elliptical cells (analogous to the generating layer in the rete Malphigii); 4, cells of the same, but already keratinized, and colourable by carmine; 5, keraphyllous lamina.

To its great vascularity is due the bright red colour it shows on its surface; this colour is sometimes masked by black pigment.

(I have found a notable quantity of adipose tissue in the cushion).

2. **Velvety Tissue.**—Much thinner than the plantar cushion, the *velvety tissue*—the formative organ of the sole and frog—extends over the whole of the plantar region of the third phalanx, as well as the plantar cushion, the bulbs of which, and the pyramidal prominence it covers, by adapting itself exactly to the irregularities of this elastic mass.

Its *surface*, which altogether resembles the general configuration of the plantar surface of the hoof, is divisible into two regions—a central, corresponding to the pyramidal body and the frog, and continuous on the bulbs of the cushion with the extremities of the coronary cushion and the perioplic ring, but chiefly with the latter; the other, peripheral, is covered by the horny sole, separated from the podophyllous tissue by the plantar border of the foot, somewhat encroached upon posteriorly by the laminæ corresponding to the bars, and is continuous, above these laminæ, with the plantar cushion.

The surface of the velvety tissue is studded with villi similar to those of the coronary cushion, and about the same size. The longest are towards the circumference of this surface, and the shortest in the median lacuna of the pyramidal body; all are lodged in the porosities on the inner surface of the horny sole and frog.

This tissue shows the same organization as the coronary cushion. The vascular corium, forming its base, is thickened at its peripheral portion by a fibrous network named the *plantar reticulum*, in the meshes of which are sustained the veins of the inferior surface of the foot.

3. **Laminal Tissue.**—This part of the keratogenous membrane is also very frequently designated the *podophyllous tissue* (and still more frequently, in this country, as merely the *laminæ*). It is spread over the anterior face of the third phalanx, occupying the interval between the plantar border of that bone and the lower margin of the coronary cushion; its width is, therefore, greater at the anterior portion of the phalanx than on its sides, where the extremities of the membrane are reflected below the bulbs of the plantar cushion on to the velvety tissue.

This membrane owes its name to the leaves it exhibits on its superficies; these are from five to six hundred in number—we have counted 560—run parallel to each other, and are separated by deep channels, into which are dovetailed analogous leaves from the inner side of the wall of the hoof; they extend from the white zone that limits the inferior border of the coronary cushion—where they are not so salient—to the plantar border of the foot, where they each terminate in five or six very large villous prolongations, which are lodged in the horny tubes at the circumference of the sole.

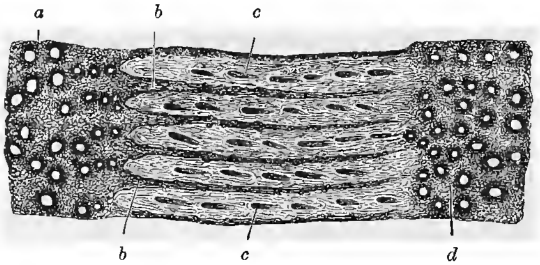
The *leaves* (*laminæ*) of the podophyllous tissue increase in width from above to below; their free margin is finely denticulated, and, under the influence of any inflammatory cause (laminitis, ablation of the horny wall), these denticulæ become largely developed, and transformed into veritable papillæ. Their sides are traversed by folds, about sixty in number, which pass uninterruptedly from top to bottom. These secondary leaves, or lamellæ, are fixed obliquely on the sides of the laminæ, as the barbules of a feather are attached to the barbs (Figs. 494, 4; 496, *c*," *c*.")

The podophyllous tissue is not in immediate contact with the keraphyllous tissue, or horny laminæ; between the two there is a mass of soft, elliptical cells, always destitute of pigment, easily stained with carmine, and appearing to stud the ramifications of the vascular laminæ (Fig. 494, 4). A transverse section of the union of the hoof with these laminæ, when treated with carmine, presents a very fine aspect, appearing as so many fern or acacia-of-Judæa leaves placed between the keraphyllous laminæ—the principal nerves and the secondary nervules of the leaves, being represented by the lamina and its lateral ridges, the limb of the leaves by the young cells spread around the latter.

The structure of the podophyllous membrane resembles that of the other parts of the keratogenous apparatus. Its corium is, like that of the peripheral portion of the velvety tissue, separated from the os pedis by a fibrous *reticulum*, which supports the veins, and forms, to some extent, the periosteum of the third phalanx.

The leaves of the podophyllous membrane are immense lamellar papillæ, which should be included among the principal instruments concerned in the tactile sensibility of the Horse's foot, and which play a really mechanical part, in concurring—by their dovetailing with the keraphyllous (or horny) laminæ—to assure the solidity of the union of the hoof with the living parts. The cells which

Fig. 495.



HORIZONTAL SECTION OF THE JUNCTION OF THE WALL WITH THE SOLE OF THE HOOF.

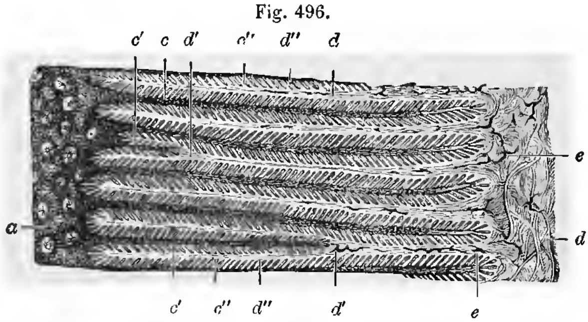
a, Wall, with its horn-tubes; *b*, *b*, horny laminæ projecting from the wall; *c*, *c*, horn-tubes formed by the terminal villi of the vascular laminæ, the horn surrounding them and occupying the spaces between the horny laminæ, constituting the "white line;" *d*, horny sole, with its tubes.

multiply on their surface have usually but little share in the formation of the horn. This will, however, be alluded to hereafter.

b. Description of the Hoof.

The hoof of the Horse—considered as a whole—represents a kind of box that envelopes the inferior extremity of the digit, by fitting closely on the keratogenous

Fig. 496.



HORIZONTAL SECTION OF THE WALL, AND HORNY AND VASCULAR LAMINÆ, TO SHOW THE JUNCTION OF THE LATTER AND THE LAMINELLÆ.

a, Inner portion of the wall with the laminæ arising from it; *b*, vascular laminæ; *c*, horny lamina of average length; *c'*, *c'*, unusually short laminæ; *c''*, *c''*, laminellæ on the sides of the horny laminæ; *d*, vascular lamina passing between two horny ditto; *d'*, vascular lamina passing between three horny laminæ; *d''*, lateral laminellæ; *e*, *e*, arteries of vascular laminæ which have been injected.

membrane, to which it is united in the most intimate manner by a reciprocal penetration of prolongations into cavities that exist on the surfaces in contact.

Its general shape is, as was demonstrated by Bracy Clark, that of the moiety of a cylinder cut obliquely across its middle, and resting on the surface of this section. In nearly all feet, however, it is slightly conical.

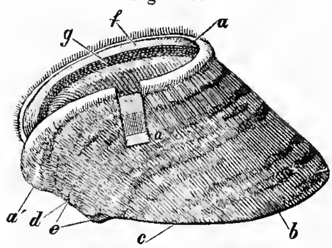
Prolonged maceration separates it into three portions—the *wall*, *sole*, and *frog*.

Wall.—The *wall*—also named the *crust*—is that part of the hoof which is apparent when the foot rests on the ground. This thick plate of horn covers the anterior face of the foot, and, gradually narrowing in width and diminishing in thickness, passes round each side until it reaches the bulbs of the plantar cushion, when its extremities are sharply inflected inwards, between the frog and internal border of the sole, becoming confounded with the latter about its middle or anterior third, after being greatly reduced in breadth and substance.

The middle—or anterior part—of this horny envelope is popularly known as the *toe;* its two sides are designated *outside* and *inside toe;* the lateral regions constitute the *quarters;* the *heels* are formed by the angles of inflection of its extremities; while these extremities themselves, passing along the inner border of the sole, are termed the *bars*.

Examined with regard to the direction it follows in its relations with the ground, this envelope is seen to be much inclined in its middle region or toe, and this obliquity gradually diminishes until the posterior part of the quarters is reached; at this point the wall is nearly perpendicular.

Fig. 497.



HOOF JUST REMOVED FROM THE FOOT (SIDE VIEW).

a, Inner surface of periople, or coronary frog-band, with some hairs passing through; *a'*, outer surface of same at posterior part of foot; *a''*, a section through the wall to show its thickness; *b* to *c*, quarter of the hoof, from *b* to the front is the outside (or inside) toe; from *c* to *d* the outside (or inside heel); *e*, frog; *f*, bevel on upper margin of wall for reception of coronary cushion; *g*, keraphyllæ, or horny laminæ.

The following are the characters it offers in the conformation of its faces, borders, and extremities:—

The *external face*, convex from side to side, and perfectly straight from the upper to the lower border, is smooth, polished, and shining: an appearance it owes to a thin horny layer, independent of the wall proper, designated the *periople*.

This *periople* forms, on the upper part of the wall, a kind of ring, continuous with the bulbs of the plantar cushion, and with the frog, of which it is only a dependency; responding, by its upper margin, to the perioplic ring, which secretes it; towards the lower part of the wall it is gradually lost, friction incessantly thinning and destroying it.

The *inner face* presents, over its entire extent, the white parallel leaves which dovetail with the laminæ of the podophyllous tissue. Collectively, these are named the *keraphyllous tissue*.

The *superior border* is bevelled off, on its inner aspect, into a circular concavity, into which the plantar cushion is received. This excavation is named the *cutigeral cavity*, because of its relations; it offers on its surface a multitude of minute openings—the commencement of the horny canaliculi which receive the villosities of the cutiduris.

The *inferior border*, in contact with the ground, and subjected to wear in unshod animals, is united inwardly, and in the most intimate manner, with the circumference of the sole.

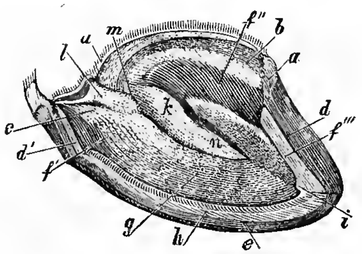
The *extremities*, constituted by the reflected and re-entering prolongations known as the *bars*, form, outwardly, the external side of the lateral lacunæ of the frog; they are provided, inwardly, with laminæ like the rest of the wall. The upper margin of these prolongations is confounded with the frog and sole; the lower appears between these two parts, and is effaced at a certain distance from the point of the frog.

Sole.—The sole is a thick horny plate comprised between the inner border of the wall and its reflected prolongations; thus occupying the inferior face of the hoof. It offers two faces and two borders or circumferences.

The *inferior*, or *external face*, forms a more or less concave surface, according to circumstances. The *superior*, or *internal face*, corresponds to the peripheral portion of the velvety tissue; it shows a multitude of little apertures analogous to those of the cutigeral cavity, into which are inserted the papillæ of the keratogenous membrane.

The *external border*, or *large circumference*, is united, throughout its extent, to the inner contour of the lower border of the wall, by means of its denticulæ,

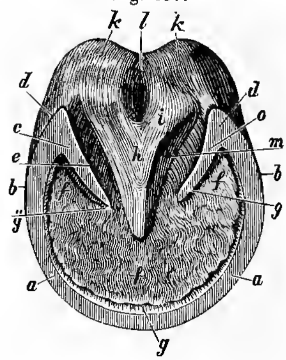
Fig. 498.



HOOF, WITH OUTER PORTION OF THE WALL REMOVED TO SHOW ITS INTERIOR.

a, *a*, Periople, or coronary frog-band; *b*, cavity in upper part of wall for coronary cushion; *c*, upper, or inner, surface of "bar;" *d*, vertical section of wall; *d′*, the same at the heel; *e*, horizontal section of ditto; *f′*, horny laminæ of bar; *f″*, ditto of wall; *f‴*, lateral aspect of a lamina; *g*, upper, or inner surface of the horny sole; *h*, junction of the horny laminæ with the sole (the "white line"); *i*, toe-stay at the middle of the toe; *k*, upper, or inner surface of the horny frog; *l*, frog-stay; *m*, cavity corresponding to a branch of the frog; *n*, ditto corresponding to the body of the frog.

Fig. 499.



PLANTAR OR GROUND SURFACE OF A HOOF (RIGHT FOOT).

The interval from *a* to *a* represents the toe; from *a* to *b*, *b*, outside and inside quarters; *c*, *o*, commencement of bars; *d*, *d*, inflections of wall at the heels, or "buttresses;" *e*, Lateral lacuna; *f*, *f*, *f*, sole; *g*, white line; *g*,′ *g*′, ditto between the sole and bar; *h*, body of frog; *i*, branch of frog; *k*, *k*, glomes, or heels of frog; *l*, median lacuna.

which are reciprocally dovetailed into those on the inner face of the wall near its inferior border. The *internal border*, or *small circumference*, is a deep, V-shaped notch, widest behind, which corresponds to the bars, and at the bottom of which the point of the frog is fixed.

Frog.—This is a mass of horn, pyramidal in shape, and lodged between two re-entering portions of the wall. It offers four *planes* (or *sides*), a *base*, and a *summit* (or *point*).

The *inferior* and the *two lateral planes* constitute the *external surface* of the organ. The first is hollowed by a longitudinal excavation, which is shallow in well-formed hoofs, and is named the *median lacuna* of the frog, separating the two salient portions, or branches, which diverge posteriorly and join the heels. The other two planes are directed obliquely downwards and inwards; they adhere closely, at their upper third, to the external side of the bars, and anteriorly to the inner border of the sole. "This union is so close that no line of demarcation is apparent between these parts, and their separation can only be obtained by prolonged maceration. The non-adherent, or free portion, forms the inner side of the cavities know as the *lateral lacunæ*, or *commissures of the frog*, whose external side is constituted by the inferior face of the bars" (Bouley).

The *superior plane*, forming the internal face of the frog, is cribbled with holes like that of the sole, and is exactly moulded on the pyramidal body of the plantar cushion. It also offers a triangular excavation, divided posteriorly into two latter channels by a prominence directed from before backwards, to which Bracy Clark gave the name of *frog-stay*, but which M. Bouley prefers to designate the *stay* (*arête*—spine or ridge) *of the frog*.

The *base* or *posterior extremity* of the frog, constituted by the extremities of its branches, forms two rounded, flexible, and elastic eminences separated from each other by the median lacuna; they cover the angles of inflection of the wall, and are continuous at this point with the perioplic band. Bracy Clark named them the *glomes* of the frog.

With regard to the *summit*—or anterior extremity of the organ—it is a point wedged in the re-entering angle comprised between the two portions of the inner border of the sole.

In the **Ass** and **Mule**, the hoof is always narrower, laterally, than that of the horse; the wall is always higher and thicker, the sole more concave, the frog smaller and deeper seated at the bottom of the excavation formed by the sole, and the horn is much more hard and resisting.[1]

(The angle of the wall of the hoof in front varies from 50° to 56°, though usually erroneously stated to be 45°. The inner face of the wall—at the middle of the toe, and in a line with the frog-stay—frequently shows a more or less salient and conical prominence—base towards the lower margin of the wall—which corresponds to a vertical depression in the os pedis. Vallada imagined that this projection served to unite the wall and sole more closely, but it is far more probable that its function is the same as that of the frog-stay—to maintain the position of the os pedis, and prevent its rotation within the hoof. I have, therefore, named it the "toe-stay.")

Structure of the Hoof-horn.—The structure of the horn has been the subject of a great number of researches; Gurlt, Delafond, Bouley, Gourdon, and Ercolani[2] have given descriptions of it, and we have also some details to add to the labours of these authorities.

The *horny substance* constituting the hoof of Solipeds, has a fibrous appearance; this is most conspicuous in the wall, less apparent in the frog and deeper portions of the sole, but impossible to distinguish in the superficial layer of the latter, where the disintegration continually taking place separates the horn in scaly fragments of varying thickness and extent. The consistence of the horn is always less in the frog than in the sole and wall. Its tint is in some hoofs black, in others white, and in others, again, a mixture of these two. The inner face of the wall, however, is never black; and when the lower part of the limb is partially

[1] The third phalanx of the anterior limb of these animals has the same shape as in the Horse, notwithstanding the lateral flattening of the hoof covering it.

[2] (The researches of Professor Rawitsch must be omitted. They will be found in vol. xxviii. of the *Magazin für Thierheilkunde*, and also in a little *brochure* entitled *Ueber den feineren Bau und das Wachsthum des Hufhorns*—Berlin: 1863. Leisering must likewise be referred to. My own researches are published in the *Veterinarian* for 1871.)

or wholly white, we may be sure that all the thickness of the wall will either be white at corresponding points in the former, or entirely so in the latter.

Except in the keraphyllous tissue, the minute structure of the hoof-horn always exhibits the same characters. Everywhere it is perforated by cylindrical canals, the upper end of which is funnel-shaped, and these contain the papillæ of the matrix, whether they belong to the coronary cushion or velvety tissue; while the lower end reaches the inferior border of the wall, or lower face of the sole and frog, according to their situation. It is rare to find them in the horny laminæ. All are rectilinear, with the exception of those of the frog, which are somewhat flexuous; and all have the same oblique direction downward and forward, following the inclination of the anterior portion of the wall. They are, therefore, almost exactly parallel to each other, not only in the same, but in two different regions. Their diameter varies considerably, though the smallest are always those of the periople; in the wall, they are smaller as they approach the outer surface.

These tubes are not mere canals hollowed out of the horny substance; on the contrary, they have very thick walls which are formed of numerous concentric layers, one within the other, and the horny tissue connecting them has not the same apparent stratiform disposition. Filled by the papillæ of the keratogenous membrane at their superior extremity, these canals are not empty for the remainder of their extent; but contain a particular white substance, which is so opaque that it appears of a fine black hue when examined as a transparency in the microscope. This matter is not deposited in a uniform manner in the canals, but irregularly, looking like a knotted cord or a necklet of beads; and where it does exist, it does not always exactly fill the calibre of the tube, an interval being observed between the inner face of the latter and the intra-tubular deposit. Sometimes it is seen outside the canals, among the concentric lamellæ, and even in the horny intertubular substance

If we are desirous of completing our knowledge of the minute organization of the hoof-horn by studying the *anatomical elements* constituting it, we shall find that it is formed of epithelial cells belonging to the kind most widespread in the economy—pavement epithelium. These horn *epithelial cells* are very thin, pale, polygonal, and generally oblong, have sharply defined borders and finely granular faces, sometimes showing a nucleus containing a single or multiple nucleolus. The nuclei sometimes occupy the centre, at other times another part of the cells—even their margins; and they also contain pigment-granules more or less coloured and numerous. Acetic acid acts very slowly on them, and is limited to making them more transparent. Potassium and soda at first softens, then distends them, causing their granulated aspect to disappear, and rounding their contours; afterwards, they become quite diaphanous, and finish by being completely dissolved

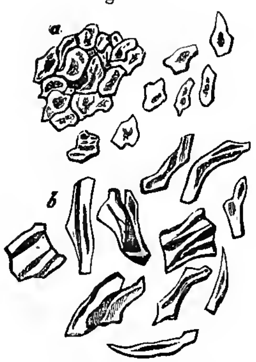
Examined in their reciprocal relations, these epithelial cells are seen not to be agglomerated comfusedly together, but are, on the contrary, disposed in a regular manner, forming a real framework that wonderfully concurs in assuring solidity and flexibility. In the walls of the tubes we see them arranged horizontally around the canal, and stratified from within to without, so as to form successive concentric layers. In the intertubular horn they are disposed differently, their stratification being no longer parallel to the direction of the tubes, but perpendicular to it, and piled upon each other in the intervals separating the latter. This change of direction does not occur suddenly; at the limits of the tubes epithelial cells are seen lying obliquely.

In a transverse section of the wall, there are observed around the tubes, in the intertubular substance, as well as in the horny laminæ, small irregularly elliptical spaces containing a solid denticulated mass of a brownish tint, which is easily stained with carmine. These bodies are more elongated in the intertubular substance than in the walls of the tubes, and have a certain resemblance to the cartilaginous capsules, but especially to the bone cavities filled by their contents.

Independently of the hard, dry, and flattened cells, there is found an opaque substance that partly fills the tubes, and which is also sometimes met with in their walls. This material does not differ from the last in its nature; it is also formed, as has been asserted by Gourdon and Ercolani, of irregular granular cells which are stained by the carminate of ammonia.

Pigment-corpuscles are found in the substance of the coloured horn, and are disposed singly, or in small masses, in the epithelial cells of the inter-tubular

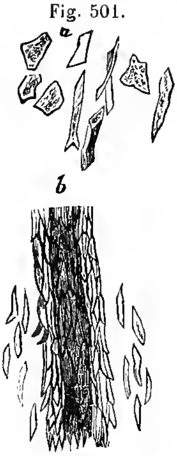
Fig. 500.



HORN-CELLS FROM THE SOLE OF THE HOOF.

a, Young cells from the upper surface of the sole; *b*, cells from the lower surface, or dead horn of the sole.

Fig. 501.



CONSTITUENT ELEMENTS OF THE WALL.

a, Horn-cells; *b*, horn-fibre from the hoof of a new-born foal, showing the vertical disposition of the cells.

substance. The presence of these corpuscles has been denied, and the coloration has been attributed to a greater condensation, at certain points, of the epithelial elements. Fine pigment-granules are disseminated in the cells, but it is evident that beyond these there are at different points pigment-corpuscles; for, after treating a section of coloured horn with soda, the epithelial elements are distended, become pale, and disappear, leaving, however, here and there, masses of black granulations. These pigmentary corpuscles are absent in white horn.

Development of the Hoof.—The hoof being a dependency of the epidermis, is developed like it—that is, by the incessant formation of cells in the layer that corresponds to the stratum mucosum. The velvety tissue forms the sole and frog; the perioplic ring the periople, and the coronary cushion the wall. In these different parts, the epithelial cells multiply, and become flattened in layers parallel to the surface that secretes them, and in proportion as they recede from that surface; so that the wall grows from its superior to its inferior border, and the other two parts of the hoof from their internal to their external face.

The villi of the coronary cushion and the velvety tissue are the organs around which the epithelial lamellæ are grouped, and their presence determines the tubular structure of the horn; their function is completed by the exhalation of a particular fluid that maintains the flexibility of the hoof, and, probably, by the development on their surface of the irregular cells which cluster in the interior of the tubes.

The laminal tissue, in a normal condition, does not concur to any extent in the development of the wall. The cells covering it are multiplied in describing a downward and forward movement; and though they are certainly applied to the inner face of the wall, yet they do not constitute the horny laminæ. The latter are formed on the coronary cushion, at the commencement of the vascular laminæ, and they descend with the wall in gliding along the surface of the layer of cells separating them from the latter; this downward movement is facilitated by the multiplication, in the same sense, of these cells. This opinion as to the function of the vascular laminæ is based on comparative anatomy, on the presence of some longitudinal tubes in the horny laminæ, and on pathological observations.

When the podophyllous tissue is inflamed—whether or not it be exposed—its latent activity is quickly manifested, and it rapidly throws out a large quantity of hard consistent horn, traversed by tubes which, according to Gourdon, are directed obliquely backwards. These tubes are more irregular than those of the normal wall, are disposed in parallel series, and are formed around the villo-papillæ developed on the free border of the laminæ. In this horn, produced by the vascular laminæ only, there are never observed between these latter the horny plates of cells—sharp and distinct in the midst of the other cells, as in those of the wall formed by the coronary cushion.

The horn thrown out on the surface of the podophyllæ, immediately after the removal of a fragment of the wall, is not a definitive horn, but must be replaced by that from the coronet. This substitution is complete; as a microscopical examination proves that the wall which descends from the cushion, and is furnished with horny laminæ, passes beneath the provisional wall, and glides downward—by the combined action already mentioned—over the surface of the soft cells of the vascular laminæ. As soon as the latter are covered by the proper wall, their marginal papillæ become atrophied, and they again assume the limited function pertaining to their physiological condition.

(The description of the disposition of the epithelial cells given by Chauveau does not quite coincide with my own observations. As he correctly states, these cells are formed in planes parallel with the surface that secretes them; consequently, around the papillæ they are more or less vertical, while between them they are horizontal. The walls of the tubes, or fibres, are therefore composed of cells disposed in a vertical manner; while in the inter-fibrous horny matter they are arranged in the opposite direction. The loose nodulated contents of the tube is composed of cells thrown off from the termination of the papilla, and corresponds to the pith of feathers. The soft cells interposed between the vascular and horny laminæ are carried down to the lower margin of the wall, where—with the elastic horn secreted by the papillæ which terminate the former—they constitute the peculiar light-coloured band, or "white line," which marks the junction of the sole with the wall (Fig. 499, *g*). This intermediate band of soft flexible horn at this point obviates tearing of the sole from the wall, and fracture of the former. The cells of the horny laminæ are more or less fusiform.

The beautiful lateral leaflets on the sides of the horny laminæ—corresponding to those on the vascular leaves—were observed by me in 1858; in 1862 they were described by Rawitsch and Ercolani, and, at a later period, by Colin of Alfort and Leisering of Dresden. They are very conspicuous in a well-prepared section—Fig. 496, *c″*, *c″*, *d″*.

It should be observed that the growth of the wall of the hoof is indefinite, but that the sole and frog, after attaining a certain thickness, exfoliate. For complete details as to the physiology of the Horse's foot, the student is referred to the *Veterinarian* for 1871.

It may here be noted that hairs and horn-tissue contain a substance named *keratin*, which is remarkable for the large proportion of sulphur existing in it in a loose or free state.)

2. The Claws of Ruminants and Pachyderms.

In the **Ox, Sheep,** and **Pig,** the plantar cushion covers the bulb of the heel of each digit, where it forms a convex mass; it extends to the insertion of the deep flexor tendons of the phalanges, in becoming triangular in shape, and thinner.

In the **Camel,** the foot rests on the ground by the lower face of the two last phalanges. These are protected by a double elastic cushion, but covered behind by a single horny sandal. The third phalanx is continued in a short and very convex claw, resembling somewhat a Dog's claw.

The *keratogenous membrane* has the same regions as in the Horse. The periople is separated from the coronary cushion by a well-marked groove, and has very large papillæ. The parietal coronary cushion is wide and flat, of a brownish tint in its upper moiety, white inferiorly; it blends behind with the velvety tissue of the plantar cushion, and ends in a point inwardly. The papillæ covering it are smaller than those of the periople and velvety tissue. The laminæ of the podophyllous tissue are nearer each other, and proportionately wider than in Solipeds; they are furnished with somewhat atrophied laminellæ.

The horny envelope enclosing the extremity of the digits of the **Ox, Sheep,** and **Pig,** is a kind of copula, having almost the form of the third phalanx; it is usually named the *claw.*

The *claw* of the **Ox** has an outer face resembling the wall of the Horse's hoof, and an inner face which is slightly concave, and marked by undulating grooves; owing to this concavity the two claws of each foot only touch at the extremities of their adjacent faces. The plantar region of the claw is slightly depressed, and but little developed; it is chiefly made up of the plantar cushion, which is covered by a thin layer of supple tubular horn. On the interior of the claw is seen a wide shallow cutigeral cavity, perforated by very fine openings, and laminæ thinner and more numerous than in the Horse's hoof. The tubes of the claw-horn are very small, being surpassed in diameter by those of the periople and sole.

Above and behind each claw are two little rudimentary horny capsules, which are named *ergots.* They are absent in the **Camel.** (Each ergot contains a small bone, which is not attached to the skeleton in Ruminants. In the **Pig,** these rudimentary claws are larger, and are connected with the bones of the leg. In this animal the horn of the claws is altogether thinner, softer, and less resisting than in Solipeds. The ergot is the representative of those digits which are apparently absent in the solid and cloven foot.)

3. The Claws of Carnivora.

In these animals, the third phalanx of the digits is enveloped in a conical horny sheath that curves downwards like the bone itself. This covering is designated the *claw*, or *nail*, and offers somewhat the same organization as the horns of Ruminants; it is developed, and grows in the same manner, as the hoof of Solipeds, its matrix being a prolongation of the corium which extends over the third phalanx, after dipping into the circular furrow at the base of that bone.

Placed at the extremity of the digital region, the claw in these animals is not utilized in locomotion, as the foot does not rest on the ground by the extremities of the digits, but by the whole plantar surface. Therefore it is, that we find on this face a kind of epidermic sandal covering five fibro-adipose tubercles—four small ones placed along the four principal digits (the fifth or thumb not being sufficiently developed to reach the ground), and a large central one, circumscribed in front by the others. This arrangement diffuses the pressure caused by the weight of the body (and, doubtless, ameliorates the concussion arising from the exertions these animals make, as well as ensures their footsteps being noiseless when approaching their prey).

In the Cat, the claws are very sharp and retractile; being capable of erection and depression in the interdigital spaces, by means of a small yellow elastic ligament passing from the second to the third phalanx. This animal's claws constitute its most powerful weapon of attack and defence.

In the Rabbit, the claws enable it to burrow in the ground: and the Dog can also employ them in this manner.

4. The Frontal Horns.

These are conical horny sheaths, more or less large and curved, and annulated transversely; they are formed by concentric layers of epithelial cells and some pigment-corpuscles. The horns grow in the same manner as the wall of the Horse's hoof. The keratogenous membrane covering the core arising from the frontal bone, like that covering the last phalanx of the Horse, has a papillary coronary portion at the base, and a laminer portion for the remainder of its extent. The coronary base forms the matrix for the horn.

(The length, direction, and general form of the horns varies in Ruminants, not only with regard to species, age, and race, but also sex. The **Bull,** in the Bovine species, generally has short, thick, powerful horns; the **Cow,** long and slender ones; and the **Ox,** large, long, and strong ones. Some breeds have no horns at all. It is the same with the **Goat** species, though generally the horns in these are long, flattened, and curved backwards and downwards. With the **Ram,** the horns are sometimes immense and very powerful, being of a spiral form. They are usually less, or altogether absent, in the **Ewe.** In the Bovine species, the transverse rings on the horns serve to indicate the age, the first appearing after two years.)

5. The Chestnuts.

This name is given to a little horny (oval or round) plate found, in the Horse, on the inner face of the forearm—in the lower third of the region, and at the upper extremity of the inner face of the metatarsal bone. It is composed of a mass of epithelial cells, arranged in tubes like the horn of the hoof. In Solipeds, the chestnut is the representative of the thumb.[1] That on the posterior limbs is absent in the **Ass**; in the **Mule** it is very small.

(In fine-bred Horses, this horny production is much less developed than in the coarser breeds. It is always smaller in the hind limbs.

6. The Ergots.

In the hind and fore legs, we also find a similar, but smaller corneous mass, growing from the skin of the fetlock, and named the *ergot*. Like the chestnut, it bears the same relative development in fine and coarse-bred horses.)

CHAPTER II.

APPARATUS OF TASTE.

The sense of taste permits the appreciation of savours, or the sapid properties of bodies.

Two nerves—the chorda tympani and the lingual branch of the ninth pair—appear at present to be the only sensory filaments endowed with the exercise of this function. They ramify in the lingual mucous membrane, which is thus made the organ of taste. (Three nerves are usually mentioned: 1. The glosso-

([1] This is very doubtful, particularly for any member of the class *Ungulata;* and from the fact that in the Rhinoceros and Tapir the second digit is perfectly developed, these epidermic appendages would be most probably larger in them than in the Horse, if they represented the pollex and hallux; however, they are altogether absent. Besides, in the anterior limb of the Horse and Ass they are above the carpus.)

pharyngeal, distributed to the superior third of the tongue. 2. The lingual branch of the fifth, distributed to the anterior two-thirds. 3. Filaments from the chorda tympani.)

The tongue and its investing membrane having been described at p. 400, their anatomy need not again be referred to; but we must glance at the organization of the latter, in considering it as the special apparatus of gustation. This will necessitate a few words with regard to the *free surface of the membrane* which comes into contact with the sapid bodies, and some considerations on the *terminations of the nerves* which transmit the impressions produced by these bodies to the brain.

FREE SURFACE OF THE LINGUAL MUCOUS MEMBRANE.—This surface is studded by a multitude of papillary prolongations, which are nearly all limited to the upper surface of the tongue, to which they give a tufty appearance. Their form and volume, as mentioned at p. 402, are very variable, according to their situation: some are microscopic, while others form voluminous caruncles; others, again, are long, conical, and filiform; another variety is round or depressed, representing a hemispherical tubercle scarcely projected beyond the general surface, or placed at the bottom of an excavation in the mucous membrane. The latter constitute the *circumvallate papillæ* (*p. circumvalatæ, p. lenticulares*), and are considered the true organs of gustation; the others are the *fungiform* (*p. capitatæ*) and *filiform papillæ*, which play a mechanical part on the surface of the tongue.

The *circumvallate papillæ* in the Horse are two in number, and situated near the base of the tongue; their diameter is so considerable that they have been named the blind or cæcal openings (*taste-pores*). They are the principal, but not the only organs of taste. Their surface is mammillated, each prominence corresponding to a single papilla, and being placed below the level of the raised border encircling them. A deep fossa surrounds them, and limits at their base a pedicle, which unites them to the other portions of the mucous membrane (see Figs. 218, 219).

The circumvallate papillæ show, around their peduncle, a band of adenoid tissue; and in their substance conglomerate glands, as in other parts of the mucous membrane. They are covered by an epithelium containing some scattered pigment-granules, the thickness of which is much diminished at the bottom of the fossa circumscribing them.

TERMINATION OF THE GUSTATORY NERVES.—The hypoglossal is the motor nerve of the tongue, the lingual the nerve of general sensibility, and the chorda tympani and glosso-pharyngeal the filaments of special sensibility: this appears to be clearly ascertained from the recent experiments and observations of Lussana. The lingual branch of the glosso-pharyngeal nerve gives gustatory sensibility to the posterior third of the tongue; the chorda tympani to the anterior two-thirds.

The gustatory nerves present—as do all those of the organs of sense—a particular mode of termination. First indicated by Axel Key, their special manner of terminating has been carefully studied by Lowen, Schwalbe, and Ranvier. According to these anatomists, the terminal nerve-tubes lose their medullary envelope, and, reduced to their axis-cylinder, are thrown out in small oval masses which might be termed *gustative bulbs* (*taste-buds*, or *taste-goblets*). Sartoli and Ranvier have seen some directly enter the epithelium around the bulbs. The *gustatory bulbs* are more particularly placed around the pedicles of the calyciform papillæ, in the substance of the epithelium. They are fusiform, their inner extremity rests on the mucous derma, where they receive the terminal nerve-tubes; and their external extremity reaches the epithelial layer, where they are seen either between two cells, or in an orifice pierced in a single pavement cell. Each taste-body is composed of a small cluster of cells, which are distinguished from each other by their character and position; those occupying the axis of the organule are the *gustative cells;* they are in communication with the nerve-tubes on one side, and on the other are furnished, for the most part, with rods which attain the free surface of the tongue. The superficial, or *protective cells*, completely envelop the preceding; they are a kind of epithelial-cells, imbricated like the skins of an onion.

These sensitive organs are very numerous in the walls of the circumvallate papillæ. Schwalbe reckoned their number at 35,000 in the papillæ of the Ox. (As many as 1760 have been counted on one circumvallate papilla of the Ox. In the *papillæ foliatæ* of the Rabbit there are from 14,000 to 15,000 taste-bulbs; in the papillæ of the Sheep and Pig about 9500). They are not met with in these papillæ only; Lowen has found them in a large number of fungiform papillæ, if not in all. There is nothing extraordinary in this, as the whole surface of the tongue may, in various degrees, appreciate savours. (Szabadföldy has described small oval or pyriform bodies, lying with their long diameter parallel to the surface. The axis-cylinders of the gustatory nerves enter these, and terminate at their lower part in a slight swelling; so that they resemble small Paccinian bodies.)

Differential Characters in the Apparatus of Taste in the other Animals.

In the domestic Mammifers, the differences in this apparatus are found in the number and variety of forms of the papillæ of the tongue.

In **Ruminants**, the circumvallate papillæ are disposed in two rows at the base of the tongue; they are smaller than in the Horse, but more numerous—about a dozen being counted in each row. In the **Ox**, the filiform papillæ are covered by a horny sheath, which renders them hard to the touch.

In the **Camel**, there are only seen five or six circumvallate papillæ, surrounded by papillæ foliatæ.

The **Pig**, like Solipeds, has only two circumvallate papillæ.

In the **Dog** and **Cat**, there are two principal papillæ, and in their vicinity some smaller calyces. The filiform papillæ are composite, and covered by a thick horny layer. Between them, regularly placed, are seen the fungiform papillæ, which have a brilliant aspect when looked at obliquely on the surface of the tongue.

In the Rabbit, the gustatory nerve-endings are buried in special papillary organs, situated on the limits of the upper surface and sides of the tongue, near its base, and named the *foliated organs*.

Comparison of the Apparatus of Taste in Man with that of Animals.

This has been already alluded to at p. 432.

CHAPTER III.

APPARATUS OF SMELL.

Preparation.—See directions for the preparation of the nasal cavities.

The sense of smell gives the appreciation of odorous emanations to animals. The active instruments of this sense are the filaments of the first pair of cranial nerves, which ramify in the upper part of the pituitary membrane; this becomes, with the cavities it lines, the *olfactory apparatus*. These parts having been already referred to at p. 523, we will pass to the other senses.

(The olfactory filaments, passing down from the olfactory ganglion, form a plexus upon the surface of the pituitary membrane. These filaments, as already noted (p. 523), differ widely from those of the ordinary cranial nerves, in containing no white substance of Schwann, but are nucleated and finely granular in structure, and resemble greatly the gelatinous form of nerve-fibres. Their distribution is limited to the membrane at the upper third of the nasal septum, the upper part of the turbinated bones, and the wall of the nasal cavities adjoining the cribriform plate of the ethmoid bone ; all this surface being covered with an epithelium of a rich sepia-brown hue. As has also been mentioned, Schultze divides these cells into two sets—*supporting cells* and *olfactory cells*. The first (Fig. 309, *a*) are described as terminating externally by truncated flat surfaces, which cannot be observed to be covered by any membrane separate from the contents of the cell. These contents appear to consist of protoplasma with a yellow granular aspect externally, while at the lower part an oval nucleus embedded in transparent protoplasm can be easily seen. At their attached end, these cells become attenuated, and may be traced inwards for a considerable distance until they expand into a broad flat sheet or plate, which is never coloured, though it frequently presents a granular appearance. The processes passing off from this appear to be continuous with the fibres of the submucous connective tissue. Towards the margin of the true olfactory region, cells perfectly analogous to these are met with, the only difference being that they present a well-defined band or seam at their free extremity, which is surrounded by a circle of cilia (Fig. 309, *c*). The cells of the second set (Fig. 309, *b*) are continuations of the nerves, and have been named *olfactory cells*. They are thin, fibrous, or rod-like bodies, terminating at the same level as the proper epithelial cells, and presenting, when traced inwards, a series of varicose swellings directly continuous with the prolongations of deeper-seated nerve-cells. Clarke states that the nerve-fibres, on reaching the base of the epithelial layer, divide into finer and finer branches, to form a network with numerous interspersed nuclei, through which they are probably connected with the olfactory cells (Fig. 309, *f*). The proper epithelial cylinders (*d*, *e*) are connected at their bases with the septa formed of the connective tissue belonging to the subepithelial glandular layer.)

CHAPTER IV.

APPARATUS OF VISION.

DESIGNED for the perception of external images rendered visible by the luminous rays, the sense of sight depends upon the excitability of the optic nerve, the terminal extremity of which is expanded as a thin membrane at the back of each *eye*. The latter is a globular organ lodged in the orbital cavity, attached to muscles which can move it in various directions, and protected by membranous and movable screens known as the *eyelids*, the play of which over the surface of the eye is facilitated by the lachrymal fluid; this keeps their inner surface constantly moist.

The *essential organ of vision*, or *globe of the eye*, will be first described; then, under the designation of the *accessory portion of the visual apparatus*, we will notice the receptacle for this globe, or *orbital cavity;* the *muscles* that move the eye; the protective membranes, or *eyelids;* the *membrana nictitans*, or *accessory eyelid;* and, lastly, the *lachrymal apparatus*, which concurs in the protection of the ocular globe by the fluid it incessantly throws out upon its surface.

Article I.—The Essential Organ of Vision, or Ocular Globe (Fig. 502).

Preparation.—The eye is removed from the orbit, and freed from the muscles and fat on its posterior surface. Its membranes may then be dissected by means of delicate instruments, and an idea formed of the structure of the eye. But in order to study the form and relations of the different membranes and media of the eye, the globe should be hardened in gradually concentrated solutions of chromic acid. When it is so hardened, sections can be made in every direction, at any distance from the axes, as the shell of the eye does not become deformed. It it is very easy to study the organization of the eye on such preparations.

The *globe*, or *ball of the eye*, is a spherical shell, the interior of which is filled with fluid or semifluid parts, named the *humours* or *media of the eye.* The wall of this shell (*tunica externa*) is formed of a continuous, very resisting, colourless envelope, limpid and translucid in its anterior portion, which constitutes the *transparent cornea;* and white and opaque for the remainder of its extent. It is known as the *sclerotica.*

On the inner face of the sclerotica is a second tunic (*tunica media*)—the *choroid:* a black membrane that lines the posterior face of the *retina* (*tunica interna*), and which, near where the two constituent portions of the external envelope unite, throws into the interior of the eye an elliptical diaphragm with a large opening in its centre—the *iris.* Immediately behind this disc is suspended or set, like a rose-brilliant, in the centre of a circular zone depending from the choroid, a biconvex body—the *crystalline lens*, one of the media of the eye, and which divides the interior of its cavity into two compartments: a posterior, very large, occupied by the *vitreous humour;* and an anterior, itself divided by the iris into two chambers of unequal dimensions, which contains the aqueous *humour.*

Viewed externally, and as a whole, the organ resulting from the union of all these parts represents a globular body, the anterior region of which corresponds to the cornea, and is more convex than the other points: a circumstance that tends to increase the antero-posterior diameter of the eye. But as this ocular sphere—to which is added, in front, this segment of a smaller sphere—is sensibly depressed from before to behind, it results that the other two principal diameters —the vertical and transversal—offer about the same dimensions as the first; Girard has even stated that the latter is the least. With an eye hardened by chromic acid, we have found that the transverse diameter measured 0·036 m., and the vertical 0·040 m. (1·417 × 1·575).

Two paragraphs will be devoted to the description of the constituent parts of the globe—one for the *membranes*, the other for the *media.*

The membranes (or *tunics*) of the eye are of three kinds. Two are exclusively fibrous, and form the framework; these are the sclerotica and cornea. The second is characterized by the association in its interior of the contractile element and of vessels; and the third is represented by the retina, which is nervous in structure.

The Membranes of the Eye.

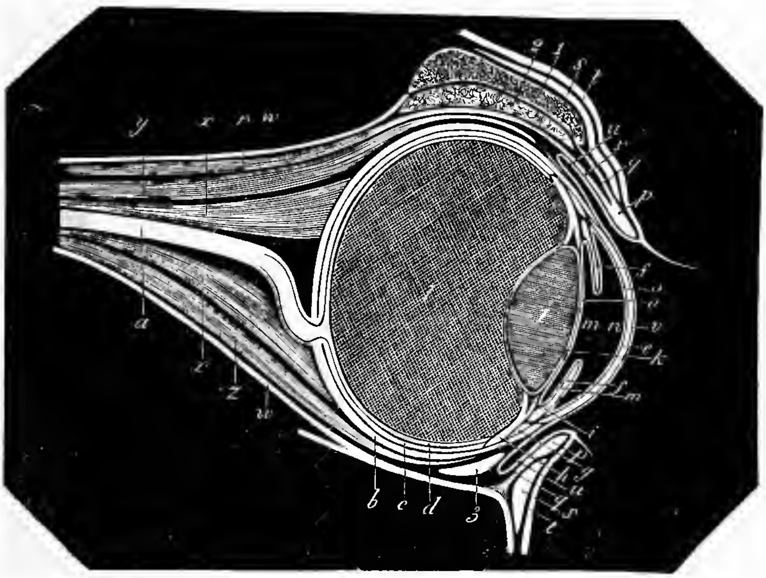
A. Fibrous Membranes.

1. The Sclerotic (Fig. 502, *b*).

The *sclerotic* is a white, very solid membrane, forming in itself about four-fifths of the external shell of the eye.

Its *external face*, in relation with the recti muscles and adipose tissue, receives posteriorly—though lower than the middle—the insertion of the optic nerve,

Fig. 502.



THEORETICAL SECTION OF THE HORSE'S EYE

1, Orbital arch; 2, lachrymal gland. *a*, Optic nerve; *b*, sclerotic; *c*, choroid; *d*, retina; *e*, cornea, *f f*, iris; *g*, *h*, ciliary ligament and processes given off by the choroid, though represented as isolated from it, in order to indicate their limits more clearly; *i*, insertion of the ciliary processes on the capsule of the crystalline lens; *j*, crystalline lens; *k*, crystalline capsule; *l*, vitreous humour; *m*, *n*, anterior and posterior chambers; o, theoretical indication of the membrane of the aqueous humour; *p*, *p*, tarsi; *q q*, fibrous membrane of the eyelids; *r*, elevator muscle of the upper eyelid; *s s*, orbicularis muscle of the eyelids; *t t*, skin of the eyelids; *u*, conjunctiva; *v*, epidermic layer of this membrane covering the cornea; *x*, posterior rectus muscle; *y*, superior rectus muscle; *z*, inferior rectus muscle; *w*, fibrous sheath of the orbit (or orbital membrane).

which passes through it and the choroid to form the retina. Its internal face is loosely united to the choroid by vessels, nerves, and connective tissue.

In front, the sclerotic shows an *elliptical opening*, the greatest diameter of which is transversal, while its border—bevelled on the inner side—is closely united to the circumference of the cornea. The substance of this membrane is traversed by numerous vessels and nerves, and is not of the same thickness throughout; at the back, around the entrance of the optic nerve, it is thickest; it then diminishes gradually towards the larger axis of the organ, and afterwards increases until it meets the cornea.

Structure.—The sclerotic is wholly composed of fasciculi of connective tissue interwoven in a very close manner, with some elastic fibres and little masses of pigment between, especially at its posterior part. Among these fasciculi, a large number pass from before to behind, and these are intersected by others which are placed in a circular manner around the globe. The superficial fibres are continuous with the neurilemma of the optic nerve. (Delicate elastic fibres are mixed with the others, and in the lacunæ of the network are some connective tissue corpuscles. Between the choroid and sclerotica is loose connective tissue containing numerous elastic fibres, and branched pigment-cells and non-pigmented flat endothelial cells; this forms the *lamina supra-choroidea*, or *lamina fusca scleræ*. The optic nerve, at its entrance into the sclerotic, is very much constricted, and passes through a funnel-shaped, porous mesh of fibrous tissue named the *lamina cribrosa*, in the centre of which is a larger opening than the others, for the passage of the arteria centralis retinæ—the *porus opticus*.)

The *arteries* of the sclerotic are derived from the anterior and posterior ciliary arteries; the *veins* pass into trunks lying parallel to the ciliary arteries. *Nerves* have been found in the sclerotic of the Rabbit, but Leydig could not find any in the Calf. Lecoq has remarked that in the Ass, particularly when it is old, the back part of the sclerotic is encrusted with an unmistakable layer of bony matter. (In Birds, bony plates are found in this region, and some Reptiles also have them.)

2. THE CORNEA (Fig. 502, *e*).

(*Preparation.*—The cornea should be removed with the sclerotic coat, by immersing the eye under water, and making a circular incision with scissors about a quarter of an inch from the margin of the membrane.)

The *cornea* is a transparent membrane forming the anterior part of the eye, to the interior of which it allows the light to pass. It closes the anterior opening of the sclerotic, and thus completes the external envelope or shell of the globe, of which it forms about a fifth part.

Elliptical—like the opening it closes—the cornea presents: 1. Two *faces*, perfectly smooth—one *external*, convex; the other *internal*—concave, forming the external wall of the anterior chamber. 2. A *circumference*, bevelled on its outer edge, and received into a similar bevel around the sclerotic opening, like the glass of a watch into its case.

STRUCTURE.—Three layers enter into the composition of the cornea—an *external*, *internal*, and *middle*.

Middle layer.—This, the *proper cornea*, is remarkable for its thickness. When pressed between the fingers, its two faces can be easily made to glide over each other—a proof that its tissue is disposed in superposed and parallel planes; it is indeed possible to decompose the cornea into several laminæ and laminellæ. These layers are formed by chondrigenous amorphous matter and connective fibrillæ, which may be disassociated by pyrogallic acid. They are perforated by more or less irregular openings, and lacunæ (*spaces of Fontana*) occupied by cells, the prolongations of which anastomose through these slits. The cornea contains in its substance a regular network of stellate cells, and of migratory cells wandering through the slits and in the lacunæ. Lecoq a long time ago remarked that this layer became opaque when the eye was strongly squeezed, and attributed this change to expression of the fluid it contained. Dubois has observed the same opacity in the cornea of the Dog, as a consequence of anæsthesia by chloride of ethylene.

In the normal condition, the transparency of the cornea results from the equal refraction of the connective tissue fibrillæ, and the chondrigenous substance surrounding them.

The *external layer* is only the conjunctival epithelium spread over the anterior face of the cornea. This epithelium in the Horse measures ·014 mm. in thickness; it is stratified, flattened on its surface, but cylindrical below, where it rests on the middle layer, and from which it is not separated—as in many other species of animals—by a proper limitary membrane.

The *inner layer* is a portion of the membrane of the aqueous humour. It is composed of: 1. A limitary membrane—the *posterior elastic lamina* (or *membrane of Descemet*)—·002 mm. in thickness, which becomes slightly fibrous at the periphery of the cornea, where it forms, in passing on to the iris, the *pectinated ligament*. 2. A lining of polygonal (flat) epithelial cells (*endothelium*), which are provided with a large nucleus.

(Some authorities give five layers to the cornea, the first being the corneal epithelium, and the second the *anterior elastic lamina*, or *Bowman's membrane*. The third consists of a very elastic tissue, perfectly structureless, and possessing a remarkable tendency to curl up; but boiling, or the action of acids, does not render it opaque, as with the other layers. Very fine fibres—*fibræ arcuatæ*—pass obliquely between it and the next layer—the *substantia propria*, or cornea proper—consisting of a large number of strata with branched fusiform cells. The fourth layer is the *posterior elastic lamina*; and the fifth layer consists of the epithelial cells already mentioned.)

Vessels.—The cornea has little vascularity in the adult. The vessels form loops around its borders, but in the fœtus they advance to near its centre.

Nerves.—These were discovered by Schlemm. They penetrate by the periphery of the cornea, and form a network on its surface. According to Kühne, Hoyer, Conheim, and Poncet, the ultimate nerve-ramifications pass into the epithelium on the anterior surface, and arrive between the most superficial cells.

(The nerves of the eyeball perforate the sclerotic in the region of the optic nerve, and run between it and the choroid anteriorly. During their course, they give off branches provided with ganglion cells, to the choroid, and, finally, they form a ring-like plexus in the ciliary region, termed the *orbiculus gangliosus ciliaris*. From this plexus branches go to the ciliary muscle, the iris, and the cornea. The nerves for the cornea pass first into the sclerotic, and form a plexus round the margin of the cornea—the *plexus annularis*—from which branches run into the conjunctiva and the cornea. The fibres entering the substance of the cornea lose their white substance, and run on as naked axis-cylinders to form networks in the different layers.)

B. Musculo-Vascular Membranes.

3. The Choroid Coat (Figs. 502, *c*; 503).

(*Preparation.*—If the cornea has not yet been removed, it and the sclerotic may now be dissected away from the choroid or second tunic. The connections between them are closest at the circumference of the iris, and at the entrance of the optic and ciliary nerves and arteries. Fine blunt-pointed scissors are necessary. A small portion of the sclerotic, near its anterior circumference, is pinched up and clipped off, the edge of the incision is raised, the circumference of the sclerotic divided, and that tunic removed piecemeal; a gentle pressure with the edge of the knife will remove it from its attachments around the circumference of the iris. This dissection is best conducted under water. The ciliary nerves and long ciliary arteries will be seen passing forward, between the sclerotic and choroid, to the iris.)

The *choroid* is a thin, dark-coloured membrane spread over the inner face of the sclerotic, the general conformation of which it repeats. It is divided into two zones by the *ora serrata*—a denticulated line which corresponds to the point where the retina changes its characters.

Posterior or choroid zone.—Throughout the whole of this zone the choroid is uniformly thin, and corresponds, by its *external face* (*superficial layer*, or *stratum of the larger vessels*), with the sclerotic; by its *internal face*, it is in contact with the retina, but does not adhere to it. Posteriorly, it shows an opening through which the optic nerve passes. In front, at the anterior opening of the sclerotic, it is continuous with the anterior zone.

The inner face (or *layer*—the *membrana-chorio-capillaris*) of the choroid is not uniform in colour, being perfectly black in the lower part of the eye; this is abruptly terminated at a horizontal line that passes about the eighth or ninth part of an inch above the optic papilla. From this line, on the segment of a circle from $\frac{2}{5}$ to $\frac{3}{5}$ of an inch in height, it shows most brilliant colours—at first blue, then an azure-blue, afterwards a brownish blue, and beyond this an intense black. The bright portion is the *tapetum* (*lucidum*, or *tapetum fibrosum*).

The background of the colour is green with bluish shades, that vary slightly according to the tint of the animal's coat. In black or dark grey Horses, the *tapetum* has a deeper blue tint than in others; and in white Horses it is sometimes yellowish brown.

(This beautiful iridescent layer is composed of numerous undulating bundles of connective tissue, contained in another layer of fine elastic fibres—the *boundary stratum of the ground substance*—placed between the two layers of the choroid.)

Anterior or ciliary zone.—This includes two parts—the "ciliary muscle" and the "ciliary body." The *ciliary muscle* (*annulus albidus*, or *musculus ciliaris*) varies in width from one to two millimètres; its external face adheres closely to the sclerotic, and its internal is continuous with the ciliary body; the posterior border is continuous with the choroid zone, near the *canal of Fontana*. The anterior border gives attachment to the greater circumference of the iris. Its structure and uses will be referred to hereafter.

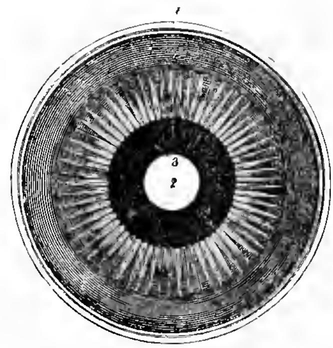
The *ciliary body* (*corpus ciliare*) forms a kind of zone or ring, wider than the ciliary muscle, and consequently overlaps the latter before and behind. It extends, on one side, on the inner face of the choroid, and on the other, on the posterior face of the iris. When the cornea and sclerotic are removed so as to expose the ciliary muscle, this zone is not seen; and to discover it, it is necessary to excise all the posterior part of the shell of the eye by a circular incision, and evacuate the vitreous humour. We then observe, around the crystalline lens, a wide, black circle, forming very regular radiating folds, projecting inwards by their inner extremities, and appearing in the posterior chamber of the eye, after cutting away the iris; all abut by these extremities on the circumference of the lens, which they do not quite reach, although the latter is sustained by, and "set" in, the centre of the ciliary body.

These radiating folds, named the *ciliary processes* (Fig. 503, 4), are from 110 to 120 in number in the Horse, and are constituted by little parallel leaves, wider at their inner than their outer extremity; the furrows that separate them posteriorly are partly concealed by the prolongation of the retina that constitutes the zonula of Zinn. The coronet formed by the ciliary processes is usually asymmetrical—that is, narrower on the inner than on the outer side.

(The elements of the ciliary muscle run in three directions: 1. *Meridional* *fibres*—numerous bundles near the sclerotic, and extending to the choroid, forming the *tensor choroideæ*. 2. *Radial fibres*, next the meridional, radiating towards the centre of the eye. 3. *Circular* or *equatorial fibres*, constituting the sphincter or *ciliary muscle of Müller*.

The ciliary muscle originates on the inner wall of a minute circular canal—named the *ciliary canal*, *canal of Schlemm*, *sinus circularis iridis*, *circulus venosus orbiculi ciliaris*, or *canal of Fontana*, from its discoverer. It is surmised to be a venous sinus, as it can always be injected from the arteries.)

Fig. 503.

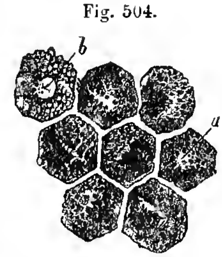


ANTERIOR SEGMENT OF A TRANSVERSE SECTION OF THE GLOBE OF THE EYE (HUMAN), SEEN FROM WITHIN.

1, Divided edge of the three tunics—sclerotic, choroid (the dark layer), and retina; 2, pupil; 3, iris (the uvea); 4, ciliary processes; 5, denticulated anterior border of the retina.

STRUCTURE.—The *choroid zone* is composed of four superposed layers: 1. The *external* is formed by a network of connective elastic fibres, among which are disseminated a great number of pigment-cells. 2. The *second layer* is constituted by a network of large arteries and veins—the posterior ciliary—and a plexus of nerves (ciliary) accompanied by ganglia and some (stellate) pigment-cells. (The veins are arranged with great regularity in drooping branches, to form the *vasa vorticosa*—Fig. 505, 2, 4; these are chiefly on the outer surface of the layer, the arteries ramifying on the inner surface.) The veins open into the ophthalmic vein. 3. The *third layer*, or *tunica Ruyschiana*, has for its basis an amorphous substance containing a network of exceedingly fine capillaries (extending to the ciliary processes). 4. The *internal layer* is composed of hexagonal cells, regularly placed one upon the other on the surface of a limitary membrane; the cells are provided with a nucleus, and contain pigment-granules which exclusively occupy their anterior moiety. (On the choroid this cell-formation is single, but on the iris and ciliary processes there are several layers. A very delicate membrane—*membrane of Bruch*, or *vitreous membrane*—has been described as lining the inner surface of the choroid, and retaining the pigment in its place; this membrane may be seen on the posterior surface of the iris, and it probably prevents the pigment being removed by the aqueous humour.) The use of the choroid membrane is to convert the ocular globe into a veritable darkened chamber, and to constitute for the retina a calefactory apparatus. (The pigment absorbs the rays of light which pass through the retina, and thus prevents their becoming reflected and confusing the vision. The brilliant metallic-coloured layer named the *tapetum* is more particularly observed in nocturnal animals, and especially in the Carnivora. By reflecting the rays of light a second time through the retina, it probably enables the animal to see better at night. It is the cause of the glare perceived in the eyes of Cats and other creatures, in the dark.)

Fig. 504.



CELLS FROM THE CHOROID COAT.

a, Pigmentary granules concealing the nucleus; *b*, the nucleus distinct.

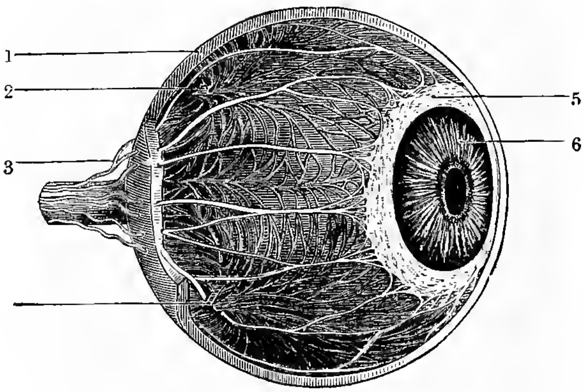
The *ciliary circle* is a contractile body, being composed of unstriped muscular fibres which are arranged in orbicular fasciculi, or extend backwards (and are lost in the choroid, behind the ciliary processes). These fibres are mixed in the plexus of ciliary nerves, on the track of which small ganglia are formed. By its contractions, the ciliary circle (or muscle) plays an important part in accommodating the eye to the perception of objects at different distances. (In Birds, the muscular fibres are striped.)

The *ciliary body* or *processes* are formed by intercrossed fasciculi of (fibrillated) connective tissue, vessels, and some unstriped muscular fibres; their inner surface is covered by pigment, like that of the choroid zone.

4. The Iris (Figs. 502, *f*; 505, 6).

The *iris* forms in the interior of the eye—at the anterior opening of the sclerotic, and in front of the crystalline lens—a veritable diaphragm pierced with a central opening—the *pupil*—which contracts or dilates according to the intensity of the light and the distance of the objects to which the vision is

Fig. 505.



THE EYE (HUMAN) WITH THE SCLEROTIC COAT REMOVED.
1, Sclerotic coat; 2, veins of the choroid; 3, ciliary nerves; 4, veins of the choroid, or *venæ vorticosa*; 5, ciliary ligament; 6, iris.

directed. This diaphragm divides the space between the cornea and the anterior face of the lens, and internal extremities of the ciliary processes, into two compartments or chambers of unequal size; the anterior space is the largest, the posterior having only a virtual existence, as the iris is close to the crystalline lens.

In shape, the iris is elliptical, like the cornea and the sclerotic aperture.

Its *anterior face* is flat or very slightly convex, and has very marked circular furrows and radiating striæ, noticeable only at the outer circumference of the membrane. It is diversely coloured, not only according to species, but also in individuals. In Solipeds, it has nearly always a brownish yellow tint; though sometimes it is nearly white or bright grey, when the animal is said to be "wall-eyed."

The *posterior face*, in relation with the lens and ciliary processes, is covered by a very thick layer of pigment named the *uvea*. Portions of this pigment, supported by a small pedicle, frequently pass through the pupillary aperture and appear in the anterior chamber of the eye, where they are known as "soot-balls," or *corpora nigra*. (There are frequently several of these black spongy masses, which are generally attached to the upper border of the pupil; on the lower margin, when present, they are much smaller. Their colour is a brownish black. They are sometimes so large as to give rise to apprehensions of injury to the vision.)

The *larger circumference* of the iris is attached to the ciliary muscle, which unites it to the choroid; it is also related to the margin of the cornea, as well as to that of the sclerotic opening.

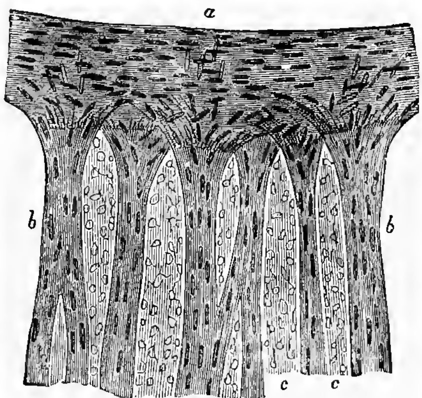
The *lesser*, or *internal circumference*, is elliptical, and circumscribes the pupillary opening.

STRUCTURE.—The organization of the iris has been much discussed; but at present it is admitted that its principal element is unstriped muscular fibre. A proper membrane and two epithelial layers enter into its formation.

The *proper membrane* has, for its framework, circular or radiating fasciculi of wavy connective tissue, with pigment-cells. Between the fasciculi are placed the unstriped fibres; these are disposed in a circular manner around the pupil to constitute the *pupillary sphincter*, and others radiate from the lesser circumference towards the ciliary ligament to form the *dilator of the pupil*. Very fine radiating vessels are disseminated among these fibres, and pass to the anterior ciliary trunks. The nerves supplied to the iris are from the ophthalmic ganglion—which has afferent nerves from the ophthalmic nerve of Willis—the common oculo-motor nerve, and the sympathetic. These nerves regulate the reflex movements of contraction and dilatation of the pupil.

(Behind the proper membrane has been described a clear, homogeneous one, composed of dense elastic substance.)

Fig. 506.



MUSCULAR STRUCTURE OF THE IRIS OF A WHITE RABBIT.

a, Sphincter of the pupil; *b*, *b*, radiating fasciculi of dilator muscle; *c*, *c*, connective tissue, with its corpuscles.

The *anterior epithelial layer* is composed of the polygonal cells of the aqueous-humour membrane, already described as existing on the posterior surface of the cornea.

The *posterior epithelial layer*, or *uvea*, is constituted by pigment-cells analogous to those of the choroid, but less regular in shape. (This pigmentary stratum—or *pars iridica retinæ*—in addition to the cells, has a fine covering—the *limitans iridis*—the continuation of the *limitans interna retinæ*.)

In the fœtus, the pupil is closed by a very thin transparent membrane—the *membrana pupillaris*. (It is identical with the anterior layer of the capsule of the crystalline lens.)

C. NERVE-MEMBRANE.

5. THE RETINA (Figs. 502, *d*; 507; 508).

(*Preparation.*—The choroid must be removed under water by means of forceps and scissors, after the lens and vitreous humour have been evacuated. A good view of the retina is to be had by looking through the vitreous humour, after the lens and iris have been excised from an eye.)

The *retina*, the essential portion of the eye—considered as the terminal expansion of the optic nerve—extends over the internal face of the choroid, from which it is easily separated, and lies between that membrane and the vitreous humour. On arriving at the ciliary body, it is exactly moulded on the radiating folds of its posterior face, and with them is prolonged to the circumference of the crystalline lens, on the capsule of which it appears to become lost, after being closely united to it. It also adheres so firmly to the ciliary processes that, in the fresh eye, it is impossible to detach it. When the eye has been kept some time, however, the two are easily separated; the cornea is removed with a portion of the sclerotic; then, dividing the iris into several pieces by diverging incisions, each is turned outwards by a slight traction that ruptures the ciliary zone and the choroid. The retina, being thus divested of the parts which cover it anteriorly, is seen to form around the lens a kind of Elizabethan ruff, dovetailing with the ciliary processes. This plaited collar has been named the *zonula of Zinn* (*zonula ciliaris*, and *ora serrata*). This zonula—the origin of which has been so much discussed—probably belongs to the vitreous humour.

At the point where the optic nerve enters the eye, there is found on the retina a small oval elevation, the larger axis of which is about $\frac{1}{5}$ inch; this little prominence is the *optic papilla*, or *punctum cæcum* (*papilla conica*). From its centre emerge the vessels of the retina.

At some distance above the *punctum cæcum*—on the antero-posterior axis of the eye—is the *yellow spot* (*macula lutea*), in the centre of which is an oval depression—the *fovea centralis*. This region is the most sensitive part of the retina.

STRUCTURE.—The retina is the most important of the three tunics of the eye, and it is also the thinnest and most delicate. It forms a soft, pulpy, transparent expansion when quite fresh, but becomes white and opalescent soon after death. Boll has discovered that, during life, the retina becomes purple in the dark, but regains its normal tint when again exposed to light. This coloration resides in the inner segment of the rod portion. Kühne has observed that the modification in the retinal purple also occurs when the eye is extirpated. The author has obtained permanent pictures of luminous objects on the retina in treating it with a 5 per cent. solution of alum. The retina-red is regenerated at the expense of the oil drops between the pigmentary layer and the retina. Capranica studied the chemical and spectroscopic characters of these drops in 1876–77.

The retina is composed of connective tissue and nerve-elements, which are arranged to form nine or ten superposed layers.

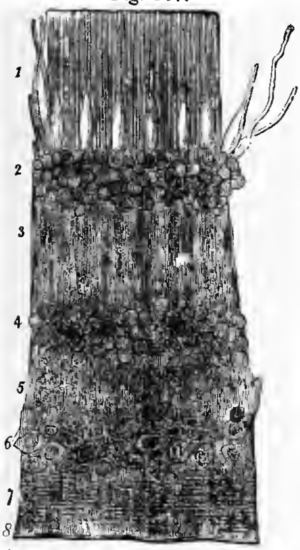
Connective Tissue.—This is very delicate and nucleated, and forms two thin layers, named the *external* and *internal limitary membranes*; these are connected by radiating fibres which pass through the nerve-elements, and anastomose very closely in the molecular layer.

Nerve-elements.—These are distributed in seven layers, which present the following characters:—

1. *Layer of rods and cones* (Fig. 507, 1).—This is also termed the *membrana Jacobi* (*bacillary* or *columnar layer*). It is situated between the inner face of the choroid and the external limitary membrane.

Rods and *cones*, regularly mixed, make up its structure. Each of these comprises two portions or segments (separated by a bright transverse line). The *outer segment* (or *shaft*) is brilliant and refractive, and consists of a small stalk terminating in a point for the cones; with a shorter stalk than the *inner segment* for the latter, and equal in length to this segment for the rods. The *inner segment* is a small granular shaft for the rods, and an enlargement, the base of which is towards the centre of the eye for the cones. The elements of this layer quickly alter after death.

Fig. 507.



VERTICAL SECTION OF RETINA.

1, Bacillar layer; 2, outer granular layer; 3, intermediate fibrous layer; 4, inner granular layer; 5, finely granular grey layer; 6, layer of nerve-cells; 7, layer of fibres of optic nerve; 8, limitary membrane.

Fig. 508.

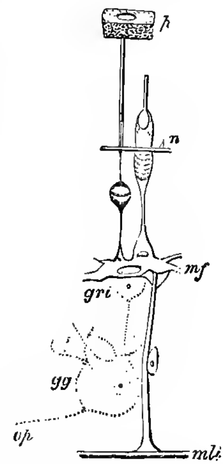


DIAGRAM OF THE STRUCTURE OF THE RETINA.

p, Pigment-cell of the retina connected with a rod; *n*, cone seated on the membrana limitans externa, the inner segment containing a cone ellipsoid, and a needle; *mf*, proper fibre connecting rod and cone with one of the cells of the membrana fenestra, the cells of which are in communication with the membrana limitans interna, *mli*, by means of a thick radial fibre with an oval nucleus attached; *gg*, multipolar ganglion of nerve-elements; *op*, optic fibrilla; *gri*, supposed connection of the nucleus with prolongation of a ganglion-cell.

2. *External granular layer* (2).—This is comprised between the external limitary and the intermediate membrane. It is formed by the *granules of the cones* and those of the *rods*—small cells with an oval nucleus (*vision cells*), furnished with an external prolongation that joins them to the base of the cones and rods, and an external varicose prolongation which often enlarges on arriving at the intermediate layer.

3. *Intermediate layer* (3).—This is very thin, and composed of flexuous fibrillæ, which are connected with the adjoining elements.

4. *Inner granular layer* (4).—In this we find cells, the membrane of which is in immediate contact with the nucleus. These cells have minute prolongments analogous to those of the external granular layer, which connect them with the surrounding layers.

5. *Molecular layer* (5).—One of the thickest, this 1 yer (the grey vesicular) presents a granulous aspect; in its mass, the connective tissue forms a close mesh, in the midst of which are seen fine fibrillæ passing in every direction.

6. *Ganglionic layer* (6).—This is composed of a single stratum of ramifying nerve-cells, the prolongations of which pass into the molecular layer, where they join the filaments of the next layer.

7. *Layer of the optic-nerve fibres* (7).—The fibres (ultimate fibrils) of the optic nerve, in passing through the sclerotic and choroid, anastomose with each other, and arrange themselves in a cone shape, the apex of which corresponds with the papilla conica; at this point they suddenly spread out in every direction, between the ganglionic layer and the internal limitary membrane.

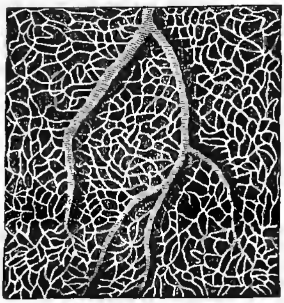
To sum up, the retina comprises the following layers, reckoning from before to behind: 1. Internal limitary membrane. 2. Layer of optic-nerve fibres. 3.

Layer of ganglion-cells. 4. Molecular layer. 5. Inner granular layer. 6. Intermediate layer. 7. Outer granular layer. 8. Outer limitary membrane. 9. Layer of rods and cones. 10. Pigmentary layer of the choroid, if this be attached to the retina, as Schultze proposes.

It is to be remarked, that at the *ora serrata* all the nerve-elements of the retina disappear.

Pigment Layer.—This is represented by a row of cells spread on the posterior face of the rod-and-cone stratum. These cells have many small prolongations, which are insinuated between the rods and cones, and the elongated or rounded pigmentary granules of a more or less dark colour.

Fig. 509.



CAPILLARIES IN THE VASCULAR LAYER OF THE RETINA.

(At the papilla conica, all the other elements than the nerve-fibres are entirely absent; hence this is presumed to be a "blind spot.")

Blood-vessels.—The retina possesses a particular vascular distribution. The *arteria centralis retinæ*, with its *vein*, enters the optic nerve at a short distance from the globe, and with it passes into the eye; they traverse the papilla, and immediately divide into two branches, one of which is directed upwards, the other downwards. Close and fine anastomoses unite the vessels of the retina with the ciliary vessels at the back of the sclerotic.

The distribution of the vessels in the different strata of the retina is variable. They are only found in the layer of nerve-fibres, in the retina of the Horse, Rabbit, and Guinea-pig; but they are seen in all the layers—that of the rods excepted—of the retina of the other animals.

THE MEDIA OF THE EYE.

1. The Crystalline Lens (Fig. 502, *j*).

The *lens*, as its name implies, is a (solid) transparent body, sustained at the smaller circumference of the zone formed by the ciliary processes (behind the pupil, and partially embedded in the vitreous humour). It is biconvex in shape, and flatter on its anterior than its posterior surface. We have measured the lens of the Horse's eye, and find the following dimensions: vertical diameter $\frac{6}{10}$ and transverse diameter $\frac{5}{10}$ of an inch. The posterior face is evidently more convex than the anterior, for we found the transverse diameter of the last to be $\frac{4}{10}$, and that of the first $\frac{3}{10}$ of an inch.

Structure.—The lens is enveloped in a transparent membrane—the *capsule*—which is not adherent to it. Its thickness is uniform in the Horse, and its tissue is slightly striated transversely; its internal face is lined by a layer of pavement epithelium. (It is a homogeneous elastic membrane, partly of cuticular formation by epithelial cells, and partly an altered product of the embryonic connective tissue.)

The *proper tissue* (*substantia propria*) of the lens is disposed in concentric layers, the outer of which are almost fluid (gelatinous), but their consistence gradually increases towards the centre. These layers are composed of hexagonal prismatic bands (the *fibres of the lens*, themselves extremely long epithelial cells) denticulated on their borders, and provided with one or more nuclei.

The epithelium on the inner face of the capsule becomes dissolved soon after death, and forms the *liquor Morgagni*, which is, consequently, nothing more than a *post-mortem* product.

The lens has neither vessels nor nerves.

In the fœtus, it receives the central artery of the retina—a branch which passes forwards through the vitreous humour and enters the posterior face of the lens; but this vessel disappears a long time before birth.

(It should be noted that the fibres of the lens pass in a meridional direction, but none go beyond the entire half of the lens—as the nearer a fibre starts from the anterior pole, the further it is removed from the posterior pole at its termination.

To examine the structure of the lens, it is best to boil it, or to immerse it in alcohol or very diluted nitric acid, which renders it hard and opaque. It is then found to be divided into three equal parts by three lines, which radiate from the centre to within one-third of the circumference; so that each of these portions is composed of hundreds of concentric layers, arranged within one another, like the coats of an onion. If any single layer is examined with the microscope, it is found to be made up of these parallel fibres, which measure about $\frac{1}{5000}$ of an inch in thickness, and are united to each other by finely serrated or scalloped borders that dovetail in the most beautiful manner.

The lens is nourished by means of the extremely delicate layer of nucleated cells on its surface, which absort nutriment from the capsule.

The use of the lens is to bring the rays of light to a focus upon the retina, they being greatly refracted in passing through it.)

2. The Vitreous Humour (Fig. 502, *l*).

The *vitreous body*, or *humour*, occupies all the cavity of the eye behind the lens (about two-thirds of the interior of the eye).

It appears to be a colourless, transparent jelly, much more fluid than the lens, and is formed of a fluid amorphous substance contained between layers of extremely delicate connective tissue, anastomosing with each other in every direction. On the surface these layers join a thicker one, contiguous to a thinner that envelops the whole mass, and named the *hyaloid membrane*. Beneath this membrane, in front, are bundles of connective tissue which gradually diverge widely forward, and become attached to the front and posterior circumference of the capsule of the lens, to constitute the zonula of Zinn.

(This humour also contains round cells like leucocytes, and stellate and spindle-shaped cells, sometimes showing vacuoles in their protoplasm. The spaces in the humour communicate freely, and are rendered apparent by freezing the eye or steeping it in chromic acid, when it is found that the humour is intersected by a large number of delicate partitions, with a cylindrical space—*canalis hyaloideus*, or the *canal of Cloquet*—in the axis, for the passage of the central artery in the fœtus. The membrane is firmer on the surface than elsewhere, so that it serves as a capsule for the humour, and suffices to keep it in shape after the outer envelopes of the eye are removed. As mentioned, the lens is maintained *in situ* by the zonula of Zinn.

This humour concurs in refracting the rays of light.)

3. The Aqueous Humour.

This is a liquid that owes its name to its great fluidity; it is contained in the anterior and posterior chambers of the eye, in front of the lens. It is secreted by a particular membrane—the *membrane of the aqueous humour*, or *membrane of Descemet* or *Demours*—an extremely thin serous layer, easily distinguished on the posterior face of the cornea, and admitted to exist on the two surfaces of the iris, the ciliary processes, and anterior face of the capsule of the lens (Fig. 502, *o*), where it is reduced to epithelium only.

Schwalbe has observed the glandular appearance of the epithelium on the ciliary processes; and Ehrlich has shown that when flourescene is injected beneath the skin, it is eliminated by the anterior chamber of the eye when the aqueous humour is evacuated by puncture of the cornea. From these facts, conclusions have been drawn as to the analogy between this epithelium and a gland. This gland is completely innervated (Schaler and Uthof, Nicati); the Gasserian ganglion is its moderator centre.

(The eyeball has no proper lymph-vessels, but it has numerous small intercommunicating spaces which are related to larger spaces—such as Schlemm's canal, the canal of Petit, the *canalis hyaloideus*, Tenon's space on the dural sheath of the optic nerve; and this arrangement allows the lymphatic system of the eye to be divided into two regions—an anterior and a posterior.

The chief function of the aqueous humour appears to be to maintain the convexity of the cornea, and to facilitate the movements of the iris and lens; as well as to assist, to some extent, in refracting the light that passes through it to the lens and retina. The rapidity with which this fluid can be regenerated is very striking; absorption also takes place very rapidly in the anterior chamber of the eye. The frequency of adhesions between the iris and lens, after attacks of ophthalmia, is accounted for by the minute quantity of this fluid that exists between them, as, owing to the smallness of the posterior chamber, this is reduced to a mere film.)

Article II.—Accessory Organs of the Visual Apparatus.

ORBITAL CAVITY.

Preparation.—The ocular cavity is prepared by clearing the temporal fossa of its muscles and adipose tissue, and removing the eyelids, also the eye and its muscles.

Situated at the side of the head, at the point corresponding to the union of the cranium and face, the *orbital cavity* is circumscribed by a bony margin, in the formation of which the orbital process, frontal, lachrymal, malar, and a small portion of the zygomatic process of the temporal bone, concur. Posteriorly, however, there are no bony walls, and the cavity—in the skeleton—is continuous with the temporal fossa. But a fibrous membrane completes this cavity in the domesticated animals, and keeps it distinct from the fossa.

Designated the *ocular sheath* (*ocular membrane*, or *periorbita*), this fibrous structure is attached, posteriorly, to the border of the orbital hiatus, and anteriorly to the inner face of the orbit; being prolonged beyond the external lip of this osseous rim to form the fibrous membrane of the eyelids. Strong externally, the ocular sheath is thin where it is in contact with the bones of the cavity. It is traversed by vessels and nerves, and is composed of a mixture of elastic and inelastic fibres. (Unstriped muscular fibres have also been described as existing in this orbital periosteum.)

Thus completed, the orbital cavity has the form of a regular hollow cone, open at its base, and closed at the apex, which corresponds to the orbital hiatus.

In the ordinary position of the head, the opening of this cone is directed forwards, downwards, and outwards.

Independently of the globe of the eye, the orbital cavity lodges the muscles that move it, the membrana nictitans, and the lachrymal gland.

(Unstriped muscular fibres have been found in this ocular sheath in Sheep and other animals, also in Man.)

Muscles of the Globe of the Eye (Fig. 510).

These are seven in number: five termed *recti muscles*, and distinguished as *posterior*, *superior*, *inferior*, *external*, and *internal*; two named *oblique*—a *large* and *small*.

(*Preparation.*—Detach the eyelids from the margin of the orbit, cutting away the lower, but leaving the upper. Saw through the zygomatic process of the temporal bone, in front of the temporo-maxillary articulation, also through the temporal process of the malar, and the base of the orbital process of the frontal bone; remove the excised piece of bone, and the temporal fossa and ocular sheath are exposed. Cutting through the latter, the muscles of the eye are seen disposed in a conical manner around the globe; dissect away the fat lodged among them, in order to isolate them.)

1. **Posterior Rectus or Suspensory Muscle** (*retractor oculi, retractor bulbi*).—This muscle completely envelops the extra-cranial portion of the optic nerve, being a muscular sheath resembling in shape the fibrous lining of the orbit. Its fibres are disposed longitudinally, arise around the optic foramen, and are inserted into the posterior part of the external face of the sclerotic. It is always more or less fasciculated, and may be frequently separated into four portions—superior, inferior, external, and internal.

In contracting, it draws the globe towards the back of the orbit. The physiological result of this movement will be noticed hereafter.

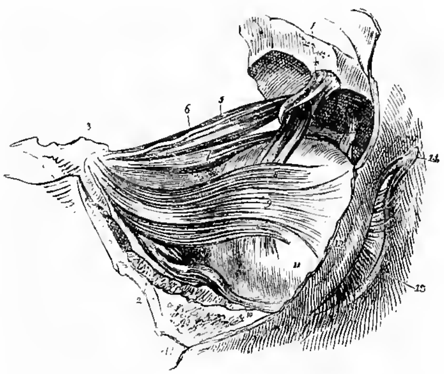
2. **Superior, Inferior, External, and Internal Recti Muscles.**—These four muscles are placed longitudinally on the preceding, and repeat, on a large scale, the disposition of its four bundles. As their borders are in contact, they constitute a fleshy sheath around it, analogous to that which it forms around the optic nerve. Exactly resembling each other, these four muscles compose so natural a group, that they may be described together. Each is a flat band, formed of parallel fibres, firmly attached by its posterior extremity to the back of the sheath, and to the interior of the subsphenoidal canal; anteriorly, it is inserted by a thin aponeurosis into the sclerotic, at the margin of the cornea. Isolated from one another, and from the retractor by the mass of fat belonging to the membrana nictitans, these small muscles are related, externally, to the ocular sheath.

There is nothing particular to be noted regarding them, their position being sufficiently indicated by their names. Their function is to bring the pupillary opening into contact with the rays of light, by inclining the cornea towards them, either upwards, downwards, inwards, or outwards; or into intermediate positions, which happens when two adjacent muscles—the inferior and external rectus, for instance—combine their action at the same moment.

3. **Great Oblique Muscle** (*trochlearis*, or *obliquus superior oculi*).—Lying to the side of the internal and superior rectus, and formed, like them, of a fleshy band terminated by a thin aponeurosis, this muscle differs from the preceding in its interrupted course. Arising from the back of the orbit, and passing forward against the inner wall of that cavity, it reaches a strong fibro-cartilaginous, pully-like process—a dependency of the aponeurosis of the orbit—attached by its extremities to the frontal bone, at the base of the orbital process; it passes through this loop, and then bends outwards, to insinuate itself below the terminal extremity of the superior rectus, and become inserted into the sclerotic, between the latter muscle and the external rectus.

This muscle pivots the eye inwards and upwards in the orbit, carrying the outer aspect of the globe upwards, and its lower part outwards; this faculty it owes to its reflection in the cartilaginous loop, as it acts as if its insertion were at the angle it forms there.

Fig. 510.



MUSCLES OF THE EYEBALL (VIEWED FROM ABOVE).

1, Section of orbital process of frontal bone to which the fibro-cartilaginous pulley, 4, of the superior oblique muscle, 5, is attached; 2, zygomatic process of the temporal bone; 3, portion of sphenoid bone into which the recti and superior oblique muscles are implanted; 6, pathetici nerve; 7, internal rectus; 8, superior rectus; 9, levator palpebræ muscle; 10, external rectus; 11, eyeball; 12, upper eyelid; 13, lower eyelid; 14, inner canthus of eye.

4. **Small Oblique Muscle** (*obliquus inferior oculi*). — Much thicker, though very much shorter than the preceding, and almost entirely fleshy, this muscle is placed in a transverse direction on the globe of the eye, being nearly parallel to the reflected portion of the great oblique. It arises in the lachrymal fossa, passes outwards, and terminates in the sclerotic, between the external and inferior recti muscles.

It is an antagonist of the great oblique, pivoting the eye in a contrary direction.

It is to be noted that the double rotatory movement executed by the oblique muscles is altogether involuntary, and that it is constantly produced when the animal inclines its head to one side—doubtless to maintain the visual axis always in identical relations with the same point of the retina. This movement is well seen in Man when the head is brought round to either shoulder: the eye then pivots in the orbit in an inverse direction to that to which the head inclines, so that a mark placed at the upper part of the iris when the head is straight would occupy the same position after the lateral movement. Simultaneous in both eyes, this pivoting is executed by certain muscles in each; the great oblique for one, the small oblique for the other, according to the direction in which the head is turned.

(A third, or *middle oblique* muscle, has been mentioned by Strangeways, as sometimes, if not always, found between the superior and inferior oblique muscles. It has been described as arising by a fine tendon from a small depression in the upper part of the orbital process of the frontal bone, between the origin of the inferior oblique and the pulley of the superior oblique muscle. This tendon is succeeded by a fusiform fleshy mass, about three lines in diameter and an inch long, embedded in adipose tissue; it passes obliquely upwards and outwards on the external face of the rectus muscle, and terminates in a thin flat tendon which accompanies the upper belly of the superior oblique for a short distance, and becomes confounded with the tendon of that muscle as it runs beneath the superior rectus. It is supposed to be an accessory of the superior oblique, and to regulate and facilitate the gliding of that muscle through the acute angle formed by its pulley.)

Protective Organs of the Eye.

1. The Eyelids (Figs. 502, 510).

Preparation.—There is no difficulty in studying the eyelids. Removing the skin carefully allows the orbicularis to be seen; in turning this up, the fibrous layer is found; and if the orbital process be removed by means of the saw, the levator palpebræ superioris is discovered in cutting away the upper part of the ocular sheath. Lastly, on an eye extracted along with the eyelids, the mode of union of these with the globe will be readily demonstrated.

The surface of the eye is covered and protected in front by two movable membranous curtains—the *eyelids* (*palpebræ*)—one *superior*, the other *inferior*.

Attached to the circumference of the orbit by their external border, the eyelids have a convex *external* face formed by the skin, and a concave *internal* face, moulded on the anterior surface of the eye, and lined by the conjunctiva, which is reflected above and below on the eyeball—the duplicatures constituting the *superior* and the *inferior conjunctival* (or *palpebral*) *sinuses*.

Each lid has also a *free border* opposed to that of its fellow, with which it unites at an angle by its extremities, so as to form two *commissures* (or *canthi*). This border is slightly bevelled on the inner side, and shows a series of small openings—the excretory orifices of the *Meibomian glands;* as well as a row of erect hairs—the *eyelashes*. These will be described presently.

When the two lids are closed by the approximation of their free borders, they completely cover the eye, and form a narrow fissure comparable to a closed button-hole. When they are separated, they circumscribe an oval space (*fissura palpebrarum*), the greater axis of which is directed obliquely downwards, forwards, and inwards. The upper contour of this space—formed by the free margin of the superior eyelid—is always more curved than the lower. The superior commissure (or canthus) has also been named the *temporal angle of the eye.* The *nasal angle*, constituted by the inferior commissure, is always rounder than the other; it lodges the *caruncula lacrymalis* (in the *lachus lachrymalis*).

Structure of the Eyelids.—A fibrous plate, terminated towards the free border of the lid by a small tendinous arch named the *tarsus;* a sphincter muscle—the *orbicularis palpebræ*—in contact with the fibrous membrane; the *levator palpebræ*—a muscle partly lodged in the ocular sheath, and terminated anteriorly by a very thin and wide expansion placed beneath the superior fibrous plate; a cutaneous envelope in two layers—an *external*, the skin, and an *internal* of mucous membrane, the *conjunctiva*, joining at the free border of the lid;—these are the elements which enter into the composition of the protective coverings of the eye.

1. **Fibrous Membrane.**—Usually thicker in the lower than the upper lid, this membrane is attached, by its adherent border, to the rim of the orbit, where

it is continuous with the periosteum and the fibrous wall of the ocular sheath. Its free border is margined by the tarsus.

2. **Tarsus.**—This is a fibrous lamella that forms a solid frame for the free border of the lid. It is elongated, narrow at its extremities, thin at its fixed border—where it is confounded with the fibrous membrane—and channeled on its inner face by several transverse parallel grooves which lodge the *Meibomian glands.* This small fibrous arc regulates the contraction of the orbicularis muscle, and prevents the lid being drawn into wrinkles ; by the rigidity it bestows on the eyelids, it allows these to meet—border to border—without puckering, when the muscle is in action.

3. **Orbicular Muscle of the Eyelids** (*orbicularis palpebrarum, musculus ciliaris Riolani*).—For a description of this muscle, see Myology, p. 279.

4. **Elevator Muscle of the Upper Eyelid, or Orbito-palpebralis** (*Levator palpebræ superioris*).—When the ocular sphincter ceases to contract, the lower eyelid droops from its own weight ; the upper lid, however, requires some special muscular agency to raise it, and this it finds in the levator palpebræ. This is a very thin, narrow, fleshy band, lodged in the ocular sheath with the other muscles of the eyeball, and is related to the superior rectus, the course of which it follows. On reaching the lachrymal gland, it expands into a wide aponeurotic membrane that passes between the conjunctiva and the fibrous plate of the eyelid, and terminates on the tarsus. (Besides ending in the *fascia palpebralis*, some of the fibres—enclosing smooth muscular fibres—pass on to the upper margin of the tarsus to constitute Müller's muscle—or *palpebralis superior.* Similar smooth fibres in the lower lid, form a *palpebralis inferior.*)

It will be seen that this muscle is inflected on the eyeball in a pulley-like manner, and it is owing to this disposition that it has the power of raising the lid. If the eyeball were not present, the muscle would draw the free margin of the lid towards the back of the orbit, instead of elevating it.

5. **Integuments of the Eyelids.**—The different layers enumerated are comprised between two tegumentary folds—the *skin* and *conjunctiva*—which are continuous at the border of the eyelids. We will examine these, with their appendages—the *eyelashes* and *Meibomian glands.*

a. Skin.—Intimately adhering, by its inner face, to the orbicularis muscle, this membrane is thin (smooth), and covered with numerous fine short hairs. In the fœtus, it shows at the orbital arch—when the skin everywhere else is nude—a well-marked semicircle of hairs—the eyebrow. Fat is never found beneath it.

b. Conjunctiva.—The conjunctiva, as its name indicates, joins the eyelids to the eyeball. Very fine and highly vascular, this mucous membrane is a continuation of the skin at the border of the lids, lines the inner face of each of them, envelopes the anterior portion of the membrana nictitans in a particular fold, covers the caruncula lachrymalis, and enters the puncta ; it is then reflected, at the adherent border of the eyelids, on to the eyeball, extending over the sclerotic and terminal aponeurotic expansion of the recti muscles. On arriving at the margin of the cornea, it is impossible to trace it further ; though it is represented by the thin layer of pavement epithelium already described. At the surface of the lachrymal caruncle, it shows some very fine hair-bulbs. It possesses some papillæ (on the palpebral portion only, the ocular reflection being thinner, and having none of these nervous processes), and tubular and aggregate glands, as well as closed follicles. We have found large numbers of the latter, the volume of which was considerable ; they form a corona around the cornea.

c. Eyelashes.—These are two rows of hairs (*cilia*) implanted in the free border of the lids, and destined to prevent the entrance of dust and small particles of foreign matter into the eye. They are much longer, and more abundant and stronger, in the upper than the lower lid, their presence there being more necessary, as extraneous particles are most likely to enter the eye when falling. But if the eyelashes of the lower lid are few and rudimentary, this is compensated for by the presence on its surface of some long bristly hairs, scattered here and there, and exactly like the tentacula of the lips.

Like all hairs, without exception, the eyelashes are flanked at their base by two or three small sebaceous glands, the duct from which opens into their follicle.

d. Meibomian glands.—These are little acinous bodies, analogous to sebaceous glands, which open alternately into a common, and very long excretory canal. They are lodged in the transverse grooves observed on the inner face of the tarsal ligaments. The unctuous matter they secrete is thrown out on the free border of the lids, and enables these to retain the tears more easily within the ocular cavity. In sick animals, this secretion accumulates at the canthi and base of the lids. (Each gland consists of a central tube, with a number of openings round its sides leading to short cæcal dilatations. The secretion also facilitates the movements of the lids.)

6. **Vessels and Nerves of the Eyelids.**—These membranous curtains receive their blood, for the most part, by the supra-orbital and lachrymal arteries, and the orbital branch of the superior dental artery. The terminal extremities of the three sensitive nerves of the eye, formed by the ophthalmic branch of the fifth pair and the orbital filaments of the superior maxillary branch, ramify in them. The anterior auricular nerve causes the orbicularis muscle to contract. The motor filaments of the levator palpebræ are derived from the third pair.

(The blood-vessels of the eyelids proceed from those which pass from the outer and inner angle of the eye; they form an arch on the inner margin of the eyelid—the *arcus tarsens externus.* After supplying the tissues, some of these vessels anastomose with the *arteria ciliaris antica.* The ocular conjunctiva has generally few blood-vessels visible in health; when inflamed, however, it becomes intensely red and vascular.

The *lymphatics* form a dense network in the tarsal conjunctiva; those in this membrane in front of the sclerotic and around the margin of the cornea, probably join the small canals of the latter. The *tunica propria* of the eyelid has many lymph-cells, and in some animals—as Ruminants—they form small lymphoid glands.

The *nerves* of the conjunctiva form a rich plexus on the margin of the eyelid, and terminate in small oval enlargements or end knobs—the *corpuscles of Krause*—which are more particularly observed beneath the corneal epithelium.)

2. Membrana Nictitans.

This organ, which is also named the *third eyelid, winking eyelid*, etc., is placed at the greater (inner) angle of the eye, whence it extends over the eyeball to relieve it from foreign bodies which may fall upon it.

It has for its framework a fibro-cartilage—reticulated or elastic—irregular in shape, thick and nearly prismatic at its base, and thin anteriorly, where it is covered by the conjunctiva; it is continued, behind, by a strong adipose cushion, which is insinuated between all the muscles of the eye, and to which it is loosely attached. No muscle directly concurs in the movements of this body; they are entirely mechanical. When the eye is in its usual position, there is only perceived the fold of conjunctiva that terminates it in front; the remainder is concealed in the fibrous case of the eye. When, however, the latter is withdrawn into the orbit by the contraction of its recti muscles, the globe compresses the fatty cushion belonging to the cartilage; this cushion, pressing outwards, pushes the membrana before it, and the latter then entirely conceals the whole front of the globe. This movement is instantaneous, but it may be momentarily checked by pressing gently on the eye when the animal retracts it within the orbital cavity.

The use of the membrana is—as will be seen from the above—to maintain the healthy condition of the eye, by removing any matters that have escaped the eyelids; and what clearly demonstrates this function, is the inverse relation that always exists between the development of this body, and the facility with which animals can rub their eyes with their anterior limbs. So it is that, with the Horse and Ox, the thoracic limb of which cannot be applied to this purpose, the membrana is very developed; in the Dog, which may use its paw to some extent when it requires to brush its eye, it is smaller; in the Cat it is still less; while in the Monkey and in Mankind, whose hands are perfect, it is rudimentary. In Tetanus, the membrana nictitans often remains permanently over the eye, in consequence of the continued contraction of the recti muscles.

(Towards the middle of the outer face of the membrana is a small yellowish-red, acinous gland—the *glandula Harderi*, firmly bound by a strong fibrous membrane to the cartilage, and surrounded by adipose tissue; it secretes a thick unctuous matter, which escapes by two or three small apertures on the inner face of the membrana.)

LACHRYMAL APPARATUS.

Preparation.—The lachrymal gland is prepared at the same time as the levator palpebrarum (see above). To dissect its excretory apparatus, melted tallow should be injected into the lachrymal canals by the nasal opening of the duct. The lachrymal bone should be chiselled away, in order to see the canal; the nasal portion can be shown in a longitudinal and vertical section of the head, made outside the median plane.

This apparatus comprises: 1. A gland which secretes the tears. 2. A series of canals that carry the superfluous fluid to the external orifice of the nasal cavities.

Lachrymal gland.—This gland, situated between the orbital process and the upper part of the eyeball—from which it is separated by the superior rectus and levator palpebræ muscles—is convex on its upper face, and concave inferiorly, in accordance with the parts it adjoins. Only little developed, it is formed of very small granules, united by fine connective tissue; from these arise minute radicles, the junction of which forms a certain number of very narrow ducts, that open on the inner face of the temporal (outer) angle of the eyelids. These are the *hygrophthalmic canals*.

The lachrymal gland secretes the tears that lubrify the anterior surface of the eye. This fluid escapes upon the organ at the temporal angle of the lids, and is carried between them and the eyeball towards the nasal angle. Its secretion is incessant, but it is increased by anything that irritates the conjunctiva, and its character may even change under the same influences.

The lachrymal gland belongs to the category of conglomerate glands; consequently, it is analogous to the salivary glands. (The gland is maintained *in situ* by a capsule formed by the fascia of the orbit.)

The hygrophthalmic canals have a thin fibrous membrane for their walls; this is covered by cylindrical epithelium.

Caruncula lachrymalis.—This name is given to a small round (or fusiform) body, frequently entirely, or partially black (or brown), slightly uneven, and situated in the nasal angle of the eye; it is nothing more than a small fold of conjunctiva covering some agglomerated follicles, and the bulbs of several fine hairs, which are readily seen on its surface. It may be regarded as designed to direct the tears towards the puncta, or to separate any extraneous particles that this fluid may carry towards it.

It has for its base a small mass of connective tissue, in the midst of which are some hair-roots, and some rather large glandules, lined by an epithelium charged with fat-granules. Nerve-tubes ramify around the hair-bulbs.

Puncta lachrymalia.—These are two little openings, situated one in each eyelid, a short distance from the nasal commissure, by which the tears pass from the oculo-palpebral surface into the lachrymal ducts.

Lachrymal ducts.—These are continuations of the last, and, like them, are very narrow; they carry the tears into the lachrymal sac. The superior is longer than the inferior duct, and arrives at the sac behind it. The mucous membrane lining these ducts is thin, and covered by a stratified pavement epithelium, similar to that of the conjunctiva.

Lachrymal sac.—This little reservoir—lodged in the indifundibulum that precedes the lachrymal foramen in the bone of that name—receives the tears from the two ducts, and passes them into the lachrymal canal. Its mucous membrane only differs from that of the ducts in being covered with ciliated epithelium.

Lachrymal canal (*nasal duct*).—The tears accumulated in the sac flow into this long duct, which extends to the lower aperture of the nostril. About one-half of its course is in the canal of the lachrymal bone, which protects it, and which terminates between the two turbinated bones. The remainder of the canal is beneath the nasal mucous membrane, whence it passes to the inner surface of the outer wing of the nostril; there it terminates by an orifice—sometimes two—that looks as if punched out of the membrane, towards the lower commissure, near the point where there is a line of demarcation between the dark colour of the skin and the rosy tint of the mucous lining.

This aperture constitutes the "nasal outlet."

The epithelium of the membrane lining the canal is ciliated in its bony, stratified in its nasal, portion. On the surface of the membrane are to be seen the openings of the secretory ducts of some racemose glands, which are lodged in the walls of the canal. Throughout its extent, the canal is lined by a continuation of the mucous membrane of the lachrymal sac. In Solipeds, this canal opens on the cutaneous surface at the entrance to the nostrils; it therefore happens that in these animals the conjunctiva, with it prolongations, forms a particular mucous membrane, independent of the great gastro-pulmonary membrane.

In the **Ass** and **Mule**, the orifice of the lachrymal canal is situated at the inner face of the outer wing of the nostril, and not near the inferior commissure, as in the Horse.

(Sometimes this outlet is double. The lachrymal secretion is not only useful in facilitating the movements of the eyelids over the eyeball, but it washes away dust and hurtful matter from off the surface of the cornea, keeping the epithelium clean, moist, and healthy.)

Differential Characters in the Visual Apparatus of the other Animals.

Essential Organ of Vision.—In the **Ox**, the eyeball resembles in shape that of the Horse; but in small animals, particularly the **Dog**, it is much more spherical. In **Birds** it is very convex in front; its largest diameter is the antero-posterior.

Sclerotic.—This is the same in all the domesticated quadrupeds. In **Birds**, however, it has some curious features. Posteriorly, it has for base a cartilaginous layer, covered on both sides by fibrous tissue; this layer frequently ossifies around the optic nerve, where it forms the posterior sclerotic ring. Around the cornea, there is the anterior sclerotic ring, composed of small bony imbricated scales, capable of moving on each other, and modifying the shape of the globe of the eye.

Cornea.—In the **Dog** and **Cat**, the structure of the cornea is similar to that of the Horse. In the **Ox, Sheep,** and **Pig**, there are two limitary membranes; one, consequently, beneath the epithelium of the anterior face. In **Birds**, this limitary membrane is thickest in front.

Choroid.—In Mammifers, there are some slight differences in the coloration of the tapetum. Thus, in the **Ox**, it is golden green, which becomes blue at the circumference; in the **Sheep**, it is a pale golden green; a golden yellow in the **Cat**; and white, bordered with blue, in the **Dog**. (It is absent in the **Pig**.) In **Birds**, it is uniformly black; this membrane has also a network of non-striped muscular fibres, and, in addition, "*Crampton's muscle*, which arises from the inner face of the osseous ring, and is inserted into the cornea" (Leydig). (According to Hassenstein, in rapacious animals there is, behind the tapetum, a layer of corpuscles composed of lime salts; to this is owing the brilliancy of their eyes in the dark.)

Iris.—In all animals the iris is muscular. In Mammifers, the contractile fibres are non-striped; in **Birds**, they are striped. (In the **Ox**, its anterior face has a brighter colour than in the Horse. In the **Sheep**, it is a brownish yellow; in the **Goat**, blue.) In the **Dog**, its colour is a more or less bright golden yellow; in the adult **Cat**, green; and in young animals, a bright blue. The pupil is elliptical in the **Ox**, as in Solipeds (in the **Sheep** and **Goat**, it is more elongated); in the **Dog**, it is circular, and, when very much dilated, it is the same in the **Cat**; but, when contracted, it becomes elliptical vertically, and may be so narrow as to represent nothing more than a thin perpendicular slit. (In the **Pig**, it is round.)

There are no differences worthy of note in the other parts of the eye.

Accessory Organs of the Visual Apparatus.—The motor and protective organs are nearly the same in all the other animals.

Muscles.—**Birds** have only six muscles—four recti, and two oblique. The latter arise from the anterior wall of the orbit; consequently, the great oblique does not pass through a pulley.

(The posterior rectus, or retractor muscle, is most developed in Ruminants, which, during their whole time of feeding, have the head in a dependent position. In most of the Carnivora, instead of this muscle forming a complete hollow cone, as in Ruminants, there are four distinct strips, almost resembling a second set of recti muscles, but deep-seated, and inserted into the posterior, instead of the anterior, portion of the globe.)

Eyelids.—The disposition of these is the same in all Mammifers. In **Birds**, the lower lid is the largest, and is furnished with a particular depressor muscle; there are no Meibomian glands. There is a third eyelid, corresponding to the membrana nictitans of Quadrupeds; it is sufficiently extensive to cover the entire front of the eye, and is moved by a curious little apparatus.

Glands.—In Ruminants, the **Pig**, and in **Birds**, there is found annexed to the membrana nictitans, *Harder's gland*—a conglomerate gland, with adipose epithelium in Mammifers, and cylindrical and granular in Birds. It secretes a thick white matter, which is thrown out on the membrana by one or two orifices. Its use is, doubtless, to favour the movements of that organ over the surface of the eye, as well as those of the eyelids. (In the **Ox**, this gland is voluminous; it has two large and several small ducts. The lachrymal gland is also voluminous, and its nasal opening is situated higher in the nostril than in the Horse. In the **Sheep**, there are found, near the lachrymal fossa, several adipose follicles, which do not properly belong to this apparatus, and which secrete a consistent, unctuous, yellow matter In the **Pig**, the lachrymal ducts are separated, by a bony partition, into two sets, as far as the lachrymal sac.)

Comparison of the Visual Apparatus of Man with that of Animals.

Essential Organ of Vision.—The *eyeball* of Man is almost spherical, as in the carnivora.

The *sclerotic* does not differ much. The *cornea* has two limitary membranes, and is much less elliptical than in Solipeds. The choroid has the same zone as in animals; it is uniformly brown. The ciliary processes, seventy to eighty in number, are a little longer than in the Horse, and do not exceed, in front, the ciliary ligament, to the inner face of which they adhere throughout their external border. The pupillary opening of the iris is always round. The *retina* is the same in structure as already described. A little above the optic papilla, there is a circular or oval patch, about $\frac{1}{24}$ of an inch in diameter, in the centre of which is a transparent spot; this is the *yellow spot* (*macula lutea*), with the *fossa centralis of the retina* (*fovea centralis, foramen of Soemmering*).

At this patch, the tissue of the retina is slightly modified, especially at the fossa; there are only cones in the columnar layer, and all the other layers appear to be confounded into one granular mass. (This spot only exists in animals which have the axes of the eyeballs parallel with each other, as in Man, the Quadrumana, and some saurian Reptiles.)

There is nothing particular in the aqueous humour, lens, or vitreous humour.

Accessory Organs of the Visual Apparatus.—The *orbital cavity* in Man is entirely enclosed by bony walls, and there is no fibrous sheath. (A fold of the orbital fascia has been described as separating the eye from its surrounding adipose tissue, and which, like a "tunica vaginalis," enables the globe to roll with rapidity and precision.) The muscles are six in number—four recti, and two oblique; the great oblique is the same as in animals. Only the rudiment of a *caruncula lachrymalis* is present. The *nasal duct* opens at some distance up on the surface of the inferior meatus.

CHAPTER V.

AUDITORY APPARATUS.

The sense of hearing—destined for the perception of sounds produced by the vibration of bodies—has for essential agents the auditory or eighth pair of cranial nerves, the terminal fibrillæ of which ramify in the membranous walls of a system of cavities forming the *internal ear*. These cavities are excavated in the substance of the petrous bone, and communicate, externally, by means of two other systems of diverticuli, which constitute the *middle* and *external ear*.

Article I.—Internal Ear, or Labyrinth.

The cavities which, together, compose this part of the auditory apparatus, being entirely channeled within the petrous portion of the temporal bone, have their walls—forming the *osseous labyrinth*—constituted by that bone. They contain the soft parts, named the *membranous labyrinth*, and fluids (*endolymph*).

The Osseous Labyrinth.

This is composed of three portions: the *vestibule*, *semicircular canals*, and *cochlea*.

Preparation.—These cavities can be seen by making sections through the petrous bone, in different directions. But it is better to expose them by cutting away this bone, after it has been softened by prolonged steeping in dilute nitric acid.

1. The Vestibule (Fig. 515, *I*).

This is a small, somewhat oval cavity, in the centre of the bone, and outside the perforated bony plate that forms the bottom of the internal auditory hiatus. It is a real vestibule, with regard to the other parts of the labyrinth, which all open into it.

On its *external wall* is the *fenestra ovalis* (*fenestra vestibuli*), an opening closed by the stapes. The *inner* wall shows the foramina through which the filaments of the vestibular branch of the auditory nerve pass. *Below*, and *in front*, is a large orifice, the commencement of the scala cochleæ ; *above*, are five little apertures, the openings of the semicircular canals.

2. The Semicircular Canals (Fig. 513).

Three in number, and very narrow, these canals owe their name to their form. They are placed above the vestibule, like three semicircular arches

Fig. 511.

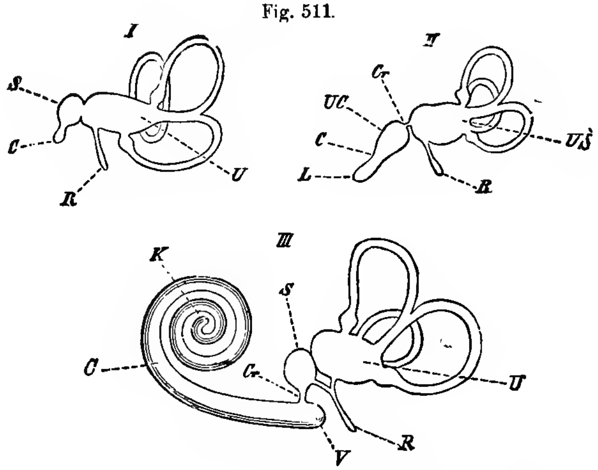


DIAGRAM OF THE LABYRINTH IN FISHES, BIRDS, AND MAMMALS
I. FISH ; II. BIRD ; III. MAMMAL.

U, Utricle ; *S*, saccule ; *US*, utricle and saccule ; *Cr*, *canalis reuniens ; R*, recessus of the labyrinth ; *VC*, commencement of the cochlea ; *C*, cochlear canal ; *L*, logenulus ; *K'*, cupola, forming the summit of the cochlear canal ; *V*, cæcum of the vestibule of the cochlear canal.

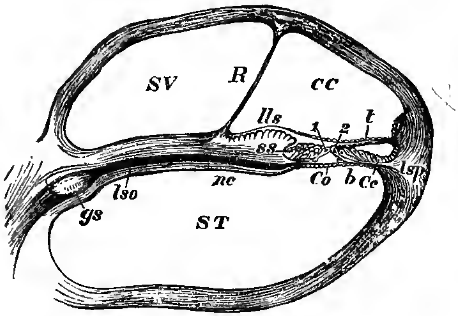
united in a triangular manner at their base, and are distinguished as *superior* or *anterior*, *posterior*, and *external*. The first two open together, by their adjacent extremities, into the vestibule ; consequently, there are only five orifices of the semicircular canals in this cavity. In addition, the adjoining openings of the posterior and external canals are so close to each other, that they appear to be sometimes united at the bottom of a short common canal.

3. The Cochlea (Fig. 514).

Situated behind, and below the vestibule, at the inner wall of the cavity of the tympanum, the *cochlea* (snail-shell) is well named, as it presents exactly the form of certain molluscs' shell. It is a spiral conical canal, twisting downwards, forwards, and upwards, around a central conical axis (the *modiolus*, or *columella*) ;

so that its centre nearly corresponds to the inner wall of the tympanum. A partition—the *lamina spiralis*, spiral like the cavity—divides it into two distinct sections, or *scalæ*—a *superior* and *inferior*. This partition is attached by its inner border to the central axis of the cochlea, but is free at its external margin, which does not quite reach the periphery of the cavity. The two scalæ, therefore,

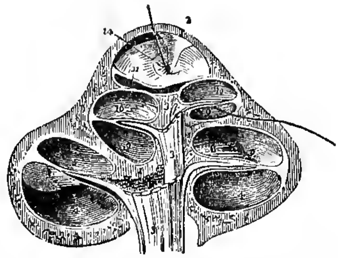
Fig. 512.



SECTION THROUGH ONE OF THE COILS OF THE COCHLEA.

ST, Scala tympani; *SV*, scala vestibuli; *CC*, canalis cochleæ; membrana of Reissner; *lls* to *lsp*, lamina spiralis membranacea; *lls*, limbus laminæ spiralis; *ss*, sulcus spiralis; *gs*, ganglion spirale situated on *nc*, the nervous cochlearis indicated by the black line; *lso*, lamina spiralis ossea; *t*, membrana tectoria; *b*, membrana basilaris; *Co*, organ of Corti; *lsp*, ligamentum spirale; *Cc*, cells of Claudius. 1, Rod of Corti of the first order; 2, rod of Corti of the second order.

Fig. 513.



SECTION OF THE COCHLEA PARALLEL TO ITS AXIS, THROUGH THE CENTRE OF THE MODIOLUS.

1, Modiolus; 2, infundibulum in which the modiolus terminates; 3, 3, cochlear nerve, sending its filaments through the centre of the modiolus; 4, 4, scala tympani of the first turn of the cochlea; 5, 5, scala vestibuli of the first turn; the septum between 4 and 5 is the lamina spiralis; a filament of the cochlear nerve is seen passing between the layers of the lamina to be distributed in the membrane investing the lamina; 8, loops formed by the filaments of the cochlear nerve on the lamina spiralis; 9, 9, scala tympani of the second turn of the cochlea; 10, 10, scala vestibuli of the second turn; the septum is the lamina spiralis; 11, the remaining half turn of the scala vestibuli; the dome above is the cupola, the line passing through it leads to the remaining half turn of the scala tympani. The osseous lamina forming the floor of the scala vestibuli curves spirally round to constitute the infundibulum, 2; 14, the helicotrema through which a bristle is passed; its lower extremity issues from the scala tympani of the middle turn of the cochlea.

communicate, in the skeleton, by means of an opening (the *helico-trema*) that follows the free border of the lamina spiralis throughout its extent.

The *inferior scala* (or *scala vestibuli*) enters the vestibule; the commencement of the *superior scale*, or *scala tympani*, is formed by the fenestra rotunda (*fenestra cochleæ*), which brings it into communication with the middle ear, without the presence of a membrane exactly closing that aperture.

The Membranous Labyrinth.

The membranous labyrinth comprises three parts, corresponding to the three cavities of the osseous labyrinth. 1. The *vestibule*. 2. The *semicircular canals*. 3. The *cochlea*.

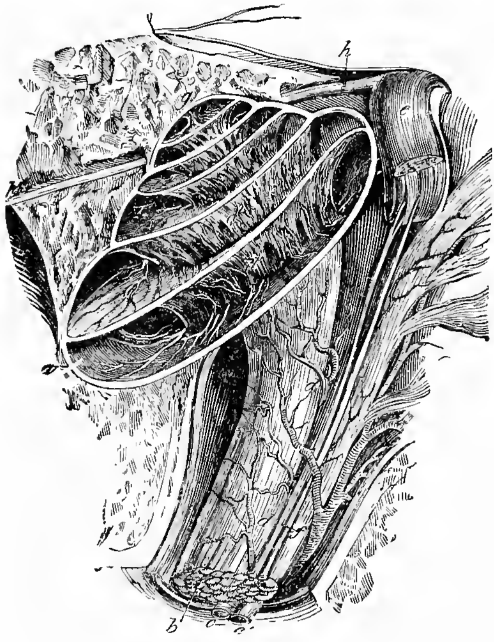
1. The Membranous Vestibule (Fig. 513).

This is composed of two sacs with thin, soft walls, lodged in the osseous labyrinth. The *superior* is the largest, is oval-shaped, and is named the *utriculus*; it communicates with the semicircular canals, of which it is a confluent. The *inferior* is smaller, spherical in shape, and forms the *sacculus;* it appears to be perfectly closed, though in contact with the utriculus.

The membranous vestibule is composed of two distinct layers—an external, of connective tissue; and an internal, *epithelial*, resting on an amorphous membrane. At the expansion of the nerve-filaments, the latter is absent, and is replaced by a white calcareous substance (minute crystalline particles of carbonate and phosphate of lime) which, in the domesticated animals, appears as a powder, and is named the *calcareous powder of the vestibule*, *ear-dust*, or *otoconites* (*otoliths*).

(Some authorities give four layers: an external or *serous*, derived from the lining membrane of the labyrinth; a *vascular*, with multitudes of vessels; a *nervous*, formed by the expansion of the filaments of the vestibular nerve; and an internal *serous* membrane, which secretes the limpid fluid contained in its interior. Spots of pigment are constantly found in the tissue of the membranous labyrinth.)

Fig. 514.



THE COCHLEA OPENED, TO SHOW THE ARRANGEMENT OF THE TWO RAMPS AND DISTRIBUTION OF THE AUDITORY NERVE.

a, Cochlea; *b*, auditory nerve; *c*, blood-vessel; *d*, *d'*, vascular ramifications; *e*, posterior part of facial nerve turned upwards; *f*, intermediate nerve of Wrisberg; *g*, summit of the cochlea; *h*, common trunks of the petrosal nerves.

2. THE MEMBRANOUS SEMICIRCULAR CANALS (Fig. 513).

These are three thin tubes, which correspond exactly with, though they are of smaller diameter than, the osseous semicircular canals; they open into the utriculus in the same manner as the latter do into the bony vestibule. Each has one of its two extremities dilated into a sac or ampulla (*sinus-ampullaceus*); for the two superior and external canals it is the anterior extremity, and for the posterior canal the outer extremity.

In structure they resemble the vestibular sacs.

3. THE MEMBRANOUS COCHLEA (Fig. 514).

The membranous cochlea is represented by two membranes, which complete the lamina spiralis; they continue the osseous laminæ of the latter, and are inserted into the external wall of the cochlea.

They give rise to three cavities, or scalæ, in the interior of this portion of the ear—an inferior, or *tympanic scala;* a superior, or *vestibular scala;* and a middle, or *auditive scala*, in which the *organ of Corti* is lodged. The vestibular scala is itself divided by the *membrane of Reissner* into two canals—the *proper* *vestibular scala*, and *Lowenberg's*, or the *collateral scala;* so that, in reality, there are four cochlean scalæ (Fig. 512).

We do not, therefore, find in the cochlea—as in the other regions of the labyrinth—a system of membranous cavities included in osseous cavities.

The structure of the membranes that limit the auditive scala is not perfectly known, and is still disputed by anatomists; but connective, epithelial, and nerve elements appear to form their base.

With regard to the *organ of Corti*, it is a very curious and interesting portion of the auditory scala, being formed of a series of solid and elastic arches resting by their extremities on the membrane—*the basilar*—that separates the auditory from the tympanic scala, their convexity being towards the superior, or *membrane of Corti.* These arches number about three thousand in Man, and are composed of two portions or articles—an external and an internal, united by a thickening in the vicinity of the membrane of Corti. To these elastic arches are added conical or fusiform ciliated cells, the function of which is to increase and transmit to the terminations of the auditory nerve, the slightest vibrations of the organ of Corti. (For further details, see works on Histology.)

Fluids of the Labyrinth.

These liquids are of two kinds—one is contained in the membranous labyrinth, the other in the osseous labyrinth.

The *fluid of the membranous labyrinth*—or *endo-lymph* of Breschet—is contained in the sacs and tubes constituting the membranous vestibule and semicircular canals. It is limpid and fluid like water. The *fluid of the osseous labyrinth*, or *peri-lymph* of Breschet, fills the two scalæ of the cochlea, and bathes the external surface of the vestibule and membranous semicircular canals, which it separates from the corresponding walls of the osseous labyrinth.

Distribution and Termination of the Auditory Nerve in the Membranous Labyrinth.

This nerve (the *portio mollis* of the seventh pair) divides, as we have said, into two branches—a *cochlear* and a *vestibular.*

The cochlear branch, the largest, reaches the base of the cochlea, where it breaks up into a large number of fasciculi, one portion of which expands over the first turn of the lamina spiralis, the other on the second, and a third on the third; the latter ramifications penetrate to the *auditory scala*, and terminate on the organ of Corti. This anatomist has seen, on the primary fibres of these ramifications, a ganglionic cell (*ganglion spiral*), at the point where they leave the *lamina spiralis ossea.* The primary fibres finally lose their myelin sheath, and, reduced to their axile filament, they terminate in the cells accompanying the arches of Corti.

The vestibular branch divides into three portions, their terminal filaments passing through the openings of the perforated spots (*foramina nervina*), and ramify in the wall of the sacculus, utriculus, and the ampullæ at the extremities of the three semicircular canals.

Article II.—Middle Ear, or Case of the Tympanum.

Excavated in the substance of the petrous portion of the temporal bone, on the limit of the petrous and mastoid sections—but chiefly in the latter—the middle ear constitutes an irregular cavity, which we may consider as composed of two *walls* and a *circumference.*

The *external wall* is principally constituted by the *membrane of the tympanum.* The *internal wall,* formed by the petrous bone, offers two openings—the *fenestra ovalis* and *fenestra rotunda*—the one situated behind the other, and separated by a small eminence named the *promontory.* The *circumference* is occupied for nearly the whole of its extent by the *mastoid cells*—large open cavities in the tympanum.

Internally, the tympanum contains a *chain of small bones* named the *malleus, incus, os orbiculare,* and *stapes ;* these bones form the medium of communication between the tympanum and the fenestra ovalis—from one wall to the other of the cavity of the tympanum.

This cavity is lined by a fine *mucous membrane,* which is continuous with that lining the pharynx, by means of a cartilaginous canal—the *Eustachian tube,* that conveys the external air to the middle ear.

We will glance briefly at the anatomical characters of the parts enumerated, and which enter into the formation of the middle ear.

1. The Membrana Tympani (Fig. 515, *B*).

Situated on the external wall of the middle ear, which it separates from the bottom of the auditory canal, this membrane is oval in shape ; its greater axis measures 11 mm. It is thin and capable of vibrating. Its *inner face,* inclining inwards and slightly convex, is adherent to the handle of the malleus. Its *external face*—forming the bottom of the auditory canal—is slightly concave (towards the meatus). The circumference is fixed in a bony frame named the *tympanal circle,* which is sharply defined, but incomplete at its upper part, and enveloped by the mastoid cells, the cavities of which radiate around this circle.

Although very thin, this membrane is composed of three layers—a middle, of a fibrous (and muscular) character (fibres radiating towards the centre, and also circular) ; an external—epidermic ; and an internal—the mucous membrane of the middle ear. It has vessels and nerves, but not in the external and middle layers. The nerves are numerous, and extend to the epithelium. (This membrane receives those vibrations of the air which set in movement the chain of bones in the ear, and thus propagates them to the fenestra ovalis and labyrinth.)

2. The Promontory, Fenestra Ovalis, and Fenestra Rotunda (Fig. 515).

Placed in the upper part of the tympanic wall, the *promontory* is only a very small eminence separating the fenestra rotunda from the fenestra ovalis. (It is marked by grooves in which lie the branches of the tympanic nerves.)

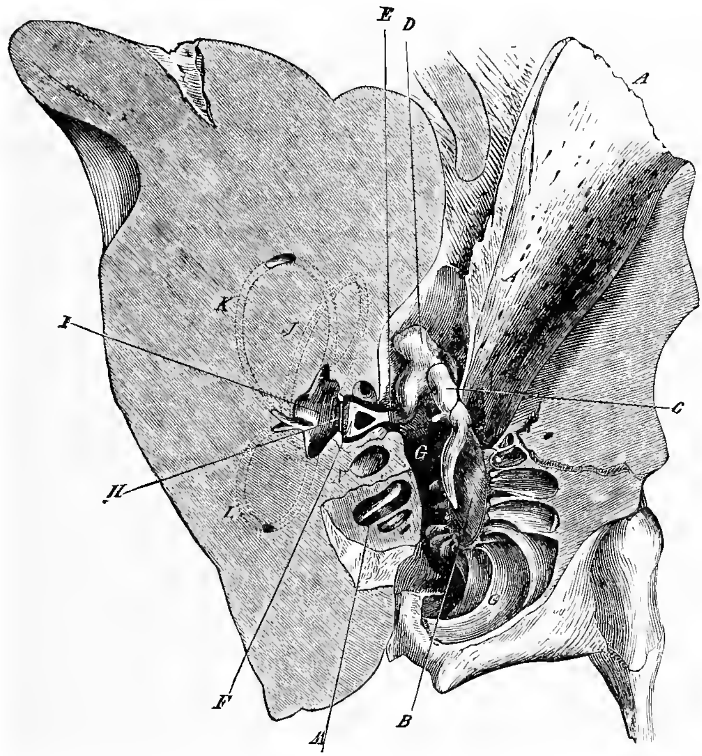
The *fenestra ovalis* (*fenestra vestibuli*), situated in front of the promontory, is an opening the form of which is sufficiently indicated by its name. It is the opening between the tympanum and osseous vestibule, and is closed by the base of the stapes. In the Horse, its average diameters are ·004 by ·002 mm.

The *fenestra rotunda* (*fenestra cochleæ*) is separated from the preceding by the promontory, and, behind this small projection, it is closed in the fresh state by a thin membrane (*m. tympani secundaria*), that forms a kind of diaphragm between the middle ear and the tympanic scala of the cochlea. Its dimensions are about the same as those of the fenestra ovalis. (The *aqueduct of Fallopius* is a canal commencing at the internal ear, passing above the fenestræa and promontory, and terminating at the mastoid foramen. It contains the facial nerve which passes through the tympanic cavity.)

3. The Mastoid Cells (Fig. 515, *G*).

These cells occupy all the circumference of the tympanic cavity, except above. They are small, more or less irregular, deep spaces, separated by thin partitions

Fig. 515.



RIGHT TYMPANIC CAVITY OF THE HORSE'S EAR (ANTERIOR PLANE, VERTICAL AND TRANSVERSE SECTION).

A, Auditory canal; *B*, membrana tympani; *C*, malleus; *D*, incus; *E*, os orbiculare; *F*, stapes; *G*, mastoid cells; *H*, fenestra ovalis; *I*, vestibule; *J*, *K*, *L*, outline of the semicircular canals; *M*, cochlea; *N*, commencement of the tympanic scala.

radiating around the tympanic circle, their free margin being turned towards the centre of the cavity.

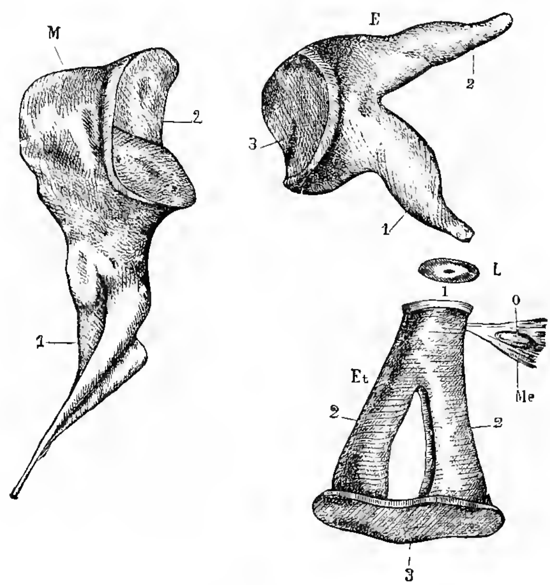
In several animals, and particularly the Carnivora, the mastoid cells form a special compartment in the tympanic case, communicating with the latter by a single opening. The largest are situated at the inferior part of the tympanic cavity, below the vaginal process of the temporal bone. (In the *Sheep* and *Goat*, the mastoid cells and their bony septa are entirely absent.)

4. The Bones of the Middle Ear (Fig. 516).

Four articulating bones (the *ossicula auditûs*), named the *malleus*, *incus*, *os* *orbiculare*, and *stapes*, compose the bony chain of the middle ear; this chain extends in a broken course from the external to the internal wall of the tympanum. The pieces are movable on each other, and are joined by *ligaments* and moved by *muscles*.

1. **Malleus** (*hammer*).—This is the longest of the bones—average length, ·011 mm.—and offers a *handle* and a *head*, which almost equally divide it. The *handle* (*manubrium*) is placed almost vertically, and is firmly fixed to the inner face of the membrana tympani. The *head*, directed upwards, has a diarthrodial facet for articulation with the incus. The *neck*, or upper part of the handle,

Fig. 516.



BONES OF THE MIDDLE EAR OF THE HORSE.

M, Malleus: 1, handle; 2, head. E, Incus: 1, inferior branch; 2, superior branch; 3, body. L, Os orbiculare. Et, Stapes: 1, summit; 2, 2, branches; 3, base. Me, Muscle of the stapes: o, bony nucleus in the terminal tendon.

shows two small processes for insertion (*processes gracilis* and *brevis*), the innermost of which is very developed.

2. **Incus** (*anvil*).—This bone presents a *body* or middle portion, and two *branches*. The *body* is channeled externally by a diarthrodial facet, corresponding with that on the malleus. Of the two *branches*, the *superior* terminates in a blunt point; while the other, *inferior*, is united at its extremity to the os orbiculare.

3. **Os Orbiculare.**—This is a little, circular, discoid bone, included between the inferior branch of the incus and stapes.

4. **Stapes** (*stirrup*).—Remarkable for its shape, which is exactly that of a stirrup, this bone is placed almost horizontally. Its *summit* (or *head*) articulates with the os orbiculare; its *middle part* is divided into two *branches*, having between them an aperture that is closed by the tympanic mucous membrane. Its base is received into the fenestra ovalis, and resembles that cavity in shape; and it is maintained in its position by the mucous lining of the tympanum, which

passes over the stapes, after being reflected around the margin of the fenestra ovalis.

(These bones transmit the vibrations of the membrana tympani to the fluid in the labyrinth.)

5. **Ligaments of the Auditory Bones.**—We need only mention the existence of these here, as they are too small and unimportant to merit a particular description.

6. **Muscles of the Auditory Bones.**—Four muscles have been described: three for the malleus, and one for the stapes. But two of these being extremely small, and their muscular character doubtful to many anatomists, we will only notice the *internal muscle of the malleus* and that of the *stapes*.

a. The internal muscle of the malleus (*tensor tympani, musculus internus mallei*).—This is a little elongated fasciculus, lodged in a particular groove in the mastoid portion of the temporal bone. It arises near the superior extremity of the Eustachian tube, and passes downwards and backwards, to terminate by a tendon which is reflected outwards, in front of the fenestra ovalis, and is inserted into the neck of the malleus.

b. Muscle of the stapes (*stapedius*).—Lodged in an excavation in the inner wall of the tympanum, near the fenestra vestibuli, on the course of the aquæductus Fallopii, this muscle is remarkable for its brevity, its relatively considerable thickness, and its conical shape. It terminates by a small tendon in front of the head of the stapes. In the Horse, Ox, and Sheep, a small bony nucleus is found in the tendon (Fig. 516, o).

(The tensor tympani retracts the bones of the ear inwards. In contracting it draws the handle of the malleus towards the cavity of the tympanum, and this brings the membrane with it; consequently, the convexity of the latter is increased and its tension is augmented. In addition, while the handle of the malleus is carried inwards, its head is turned outwards by a pivoting motion, and this pulls the body of the incus also, the long process of which is raised and inclined inwards, pushing the os orbiculare and stapes towards the fenestra ovalis. The base of the latter bone being in contact with the fluid in the vestibule, this is stirred; so that this muscle likewise acts indirectly in producing the undulations in this fluid. The muscles of the tympanum are classed as *tensors* and *laxators*. It is well to know that *all* are tensors, and none of them act as relaxors; relaxation of the membrane occurring when the muscles are not in action.)

5. The Mucous Membrane of the Tympanum.

Very fine and vascular, this membrane covers all the angularities of the middle ear, is reflected on the chain of bones, and is continued into the mastoid cells. It is continuous with that lining the Eustachian tube, and therefore should be considered as a prolongation of the tegumentary membrane spread over the walls of the pharyngeal vestibule. It is covered by a simple pavement epithelium.

6. The Eustachian Tube.

The *Eustachian tube* is a fibro-cartilaginous canal between the cavity of the middle ear and the pharynx.

Extending in a straight line beneath the base of the cranium, from the tympanic case to the upper and lateral part of the pharyngeal cavity, this canal is also named the *guttural duct* of the tympanum. It is nearly four inches long in Solipeds, is flattened on both sides, and bordered by the stylo-pharyngeus muscle. Its *upper* or *tympanic orifice* is narrow; the *inferior*, *guttural*, or *pharyngeal orifice*, situated near and behind the guttural openings of the nasal cavities, is wide, and represents a great slit extending obliquely downwards and outwards; the contiguous borders of this aperture are sustained by a cartilaginous plate—a kind of pavilion formed by the expansion of the tissue constituting the base of the tube.

Throughout its length, the guttural duct is cleft inferiorly, and by this long aperture the mucous membrane escapes and descends to form the large sac peculiar to Monodactyles, known as the *guttural pouch*.

7. The Guttural Pouches.

The mucous membrane lining the Eustachian tube is continuous, forward, with that of the pharynx; above and behind, it is prolonged into the tympanic cavity, which it lines. Below, it is dilated, and forms the *guttural pouch.*

Two in number—one being on each side—the guttural pouches lie against each other in the median plane, and descend to the larynx, where they terminate in a *cul-de-sac* constituting their *fundus*. Before and behind, they extend from the anterior part of the pharynx to the inferior face of the atlas. The capacity of each is about $\frac{3}{4}$ of a pint; but in consequence of the extensibility of the mucous membrane, the extent and capacity of the guttural pouches are particularly variable.

Irregular in shape, like the space which it occupies, the guttural pouch corresponds, behind and above, with the base of the occipital and sphenoid bones. When this reservoir is distended, its lower part, or *fundus*, descends on the lateral portions of the pharynx and larynx, to the lower extremity of the parotid gland, in the loose connective tissue of that region.

Externally, the guttural pouch contracts numerous different relations in the *intermaxillary* and *parotideal regions*, and in its *posterior* portion.

a. In the *intermaxillary* region, it is in relation with the tensor palati, pterygoideus and hyo-pharyngeus muscles, as well as with the internal maxillary artery and lingual nerve; it envelops the large cornu of the hyoid bone, and covers the inner face of the internal pterygoideus muscle.

b. In the *parotideal region*, the guttural pouch responds, above, to the inner face of the parotid gland, from which it is separated by the auricular vessels and nerves; a little lower, at the posterior angle of the hyoid bone, to the stylo-hyoideus muscle and the styloid process of the occipital bone; here the auricular artery passes obliquely upwards and backwards, and the membrane of the pouch is more closely united to the parts covering it.

Below this, the guttural pouch is in relation with the stylo-maxillaris muscle, external carotid, and the nerves forming the guttural plexus such as the ninth and twelfth pairs, the sympathetic, etc. Lower, it is related to the parotid gland, to the inferior extremity of which it may be prolonged.

c. Posteriorly.—The guttural pouch is in relation with the atlas, flexor muscles of the head, occipital artery, etc.; it forms a fold that envelops principally the pneumogastric and sympathetic nerves, and, anteriorly, another fold that encloses the internal carotid.

The *mucous membrane* of the guttural pouches is thicker and stronger than that lining the Eustachian tube and the cavity of the tympanum. Only slightly adherent to the adjacent parts, except at the branch of the hyoid, the inner face of the stylo-hyoideus, etc., it is smooth internally, and lubrified by the mucus it secretes. It may become the seat of purulent collections, which compress the larynx and obstruct the respiration, and it is in such cases that the pouch is punctured.[1]

This membrane receives numerous fine *vascular* and *nervous* ramifications from the neighbouring branches.

The guttural pouches communicate with the pharynx and cavity of the tympanum, and usually contain air ; the quantity of this may vary in health, according to the degree of dilatation of these membranous sacs. Their dilatation is chiefly produced by the palato-pharyngeus muscle, several fibres from which extend to their mucous membrane ; and, besides, when the ear is erected this membrane is thrown into a state of tension, through the adhesion of the lower prolongation of the concha to its surface.

The functions of the guttural pouches are far from being well known. It cannot be affirmed that they increase phonation ; indeed, their use appears to be rather related to audition, if it be considered that these annexes of the guttural duct of the tympanum coincide, in Solipeds, with a less development of the mastoid cells than in the other animals.

With regard to the Eustachian tube, it serves to renew the air in the tympanic cavity, this renewal being indispensable to the perfect accomplishment of hearing.

The epithelium lining the guttural pouches is cylindrical and vibratile.

(It is essential that the equilibrium between the external air and that in the cavity of the tympanum should be maintained, in order to avert irregular tension, or even rupture, of the membrana tympani. Perosino states that the guttural pouches are filled with warm air during expiration, and that this is partly changed for cold air in inspiration.)

Article III.—The External Ear.

The external ear comprises the *external auditory canal*, and a widened appendage opening outwardly, designated the *concha*, or *pavilion*.

The External Auditory Canal.

This canal (*meatus auditorius externus*), described in the Osteology, is, in the Horse, of a cylindro-conical shape, and has an average width of ·020 to ·022 m. It has at the bottom the membrana tympani, which separates it from the middle ear. Its axis forms with the surface of that membrane an angle of about 30°. Its entrance—the *external auditory hiatus*—gives attachment to the infundibulum of the conchal apparatus. It is lined by a thin integumentary membrane, intermediate in character between the skin and mucous membrane, and has in its substance a large number of glands and convoluted tubes, analogous to the sudoriparous glands—but here named *ceruminous glands*, as they secrete an unctuous matter—the *cerumen*.

The Concha, or Pavilion.

The external trumpet-shaped appendage named the concha (*concha auris*) varies much in shape in the different animals, though in all it offers the same details in organization—a *cartilaginous framework* composed of three pieces,

[1] Barthélemy, sen., and Goubaux, have found, in the guttural pouches, solid masses formed of mucus and epithelial cells.

muscles to move these, an *adipose cushion* to ensure liberty of movement, and *integuments* covering the whole.

1. Cartilages of the Concha (see p. 281).

2. Muscles of the External Ear (see p. 281).

3. Adipose Cushion of the External Ear.

This cushion, which is never absent—even in the most emaciated animals—envelops the base of the concha in front, inwardly, and posteriorly. It facilitates the movements of that organ.

4. Integuments of the External Ear.

The skin covering the concha is covered with fine close hairs. That lining its interior is very thin and vascular, adheres closely to the cartilage, and is furnished with long silky hairs, to prevent the entrance of dust into the ear.

Differential Characters in the Auditory Apparatus of other than Soliped Animals.

In the various kinds of animals we study, there are no notable differences in the *internal ear*.

In the *middle ear*, there are some modifications, either in the bones or accessory parts. In **Ruminants**, the auditory bones are like those of the Horse, except that the handle of the *malleus* is more curved, and the body of the *incus* is longer. In the **Dog**, the handle of the *malleus* is covered with small, pointed processes, and the *branches of the stapes* are long and thick. In the **Pig**, the branches of the latter are slight and inflected, and the base is wide and thin; in a word, the stapes of this animal bears no resemblance to a stirrup; the *malleus* is very much inflected forward. In the last two animals, no osseous nucleus is found in the tendon of the stapedian muscle.

It is needless to say that the fenestra ovalis varies with the base of the stapes. (The absence of the mastoid cells in the **Sheep** and **Goat** has been already noted.)

The *Eustachian tube* exists in all the animals, but the guttural pouches are only found in Solipeds.

In the *external ear*, the *conchal cartilage* varies much in shape. It is thin, inclined outwards, and widely open in **Ruminants**. In the **Pig**, it differs a little, according to breed, though it is always much developed, sometimes erect, but most frequently drooping. In the **Dog**, it is sometimes short and erect, sometimes broad and pendulous. It is always short, pointed, erect, and open in front, in the **Cat**. (In this animal a small duplicature of the external margin of the concha is often seen.) In **Birds**, the external ear is limited to the auditory canal.

Comparison between the Auditory Apparatus in Man and that of Animals.

There is nothing to be said regarding the *internal ear*. The middle ear comprises the same parts as that of Mammifers other than Solipeds. The handle of the *malleus* is straighter, the *incus* more voluminous, and the *stapes* thinner, proportionately, than in animals. There is no bony nucleus in the *stapedian muscle*. The *muscle of the malleus* is lodged in a distinct canal belonging to the Eustachian tube.

The *external ear* is composed of only two cartilages: one, forming the base of the concha, represents that cartilage in animals; the other, belonging to the auditory canal, resembles the annular cartilage in the Horse. The *concha* is very irregular in shape, and stands at an angle of from 15° to 45° from the temporal bone; it is convex superiorly, and terminates inferiorly by a small *lobe*. On its anterior face it presents prominences and depressions; the former are four in number: the *helix*, a fold encircling the ear behind and above; the *antihelix*, a concentric prominence, almost parallel with the preceding; the *tragus*, a triangular, pointed process, covered with hair, situated in front of the auditory canal (*meatus*); the *antitragus*, opposite the tragus, behind the canal, and above the lobule. The depressions are: the *concha*, a wide cavity, limited by the antihelix; the *scaphoid fossa* (*fossa innominata*) situated above the latter; and the *fossa triangularis* comprised between the helix and antihelix.

The pavilion of the ear is traversed by several muscular fasciculi, which can have no influence on its movements. The concha has also extrinsic muscles—the *anterior auricularis* (*attrahens aurem*), *auricularis superioris* (*attolens aurem*), and the *auricularis posteriores* (*retrahens aurem*). The action of these on the concha is very slight.

BOOK VIII.

GENERATIVE APPARATUS.

Individuals in the organic kingdom possess the faculty of reproduction, and thus they perpetuate the species to which they belong. In Mammifers, the *generation* of a new being demands the concurrence of two individuals—a *male* and *female*—who have intercourse under certain determinate circumstances. The female furnishes a germ—the *ovum*, and the male a fertilizing fluid—the *semen*, which vivifies the ovum, and renders it capable of development.

We have, therefore, to study separately the *generative*, or *genital organs of the male*, and those of the *female*.

CHAPTER I.

GENITAL ORGANS OF THE MALE.

The semen is elaborated in the structure of the two *testicles*. These are lobular glands, each of which is provided with an excretory duct, doubled a great number of times on itself at its commencement, to form the *epididymis*, and destitute of convolutions for the remainder of its extent, which is named the *vas deferens*. This canal carries the fecundating fluid into *vesiculæ seminales*—reservoirs with contractile walls—where it accumulates, and wnence it is expelled during copulation, by passing through the *ejaculatory ducts* and the *urethral canal*. The latter is a single canal common to the two apparatuses of generation and urinary depuration ; it is provided in its course with three accessory glands—the *prostate* and *Cowper's glands*, and is supported by an erectile body (the *corpus cavernosum*), with which it forms an elongated organ—the *penis*, which, in the act of copulation, is introduced into the vagina, to the bottom of which it carries the spermatic fluid.

We will successively consider the *secretory organs* or *testicles*, and the *excretory apparatus*, comprising all the other organs.

Preparation.—To see the arrangement of the male generative organs properly, it is necessary to dissect them *in situ*, and then remove them from the pelvis in order to examine them thoroughly.

The subject in which the organs are to be examined *in situ* should have the skin removed from it, except at the parinæum, scrotum, a portion of the inner face of the thighs, and the inferior surface of the abdomen, from a transverse line passing from one haunch to the other. The intestines are taken from the abdominal cavity, by dividing its walls in front of that line; the left posterior limb is removed, leaving the sacro-sciatic ligament which is behind it. Finally, after distending the rectum and bladder, which have previously been emptied—the first with tow, the second with air introduced by the ureter, which is then tied on itself—the dissection of the internal genital organs can be proceeded with. This dissection is carried out as for as the bladder and anus, the cellulo-adipose tissue being removed from the bottom of the pelvis, taking care to leave the peritoneum, where it passes on to the pelvic organs. The portion of the ischium to which no organ required for this study is attached, may be sawn off.

In detaching the skin from the inner surface of the thigh, and as far as the middle line, the fixed portion of the penis and one of the dartos sacs are exposed. The separation of the scrotum from the dartos is a laborious operation, because of the fineness and the adherence of the skin; it ought to be effected by means of a good scalpel, and with every precaution. The preparation is completed by dissecting the suspensory ligaments of the corpus cavernosum, the penis, and the prepuce (sheath), about which there is no difficulty.

(The dartos and other layers within the scrotum are more easily dissected, if the skin be drawn tight over the testicle and tied between the latter and the abdomen, so as to keep it tense on the surface of the organ.)

The Testicles, or Secretory Organs of the Semen.

The *testicles* (*testes*) are two glands suspended on each side of the penis, between the thighs, where each occupies a particular serous pouch—the *tunica vaginalis*. We will commence by describing this cavity, and afterwards the organ it contains.

1. Tunica Vaginalis.

The *tunica vaginalis*, in the domesticated animals, is only a diverticulum of the abdominal cavity, the serous membrane of which—the peritoneum—becomes hernied in the inguinal canal—passing, as it does, through the upper (internal) inguinal ring, and prolonged below the inferior (external) ring, so as to form a serous sac, which is enveloped by membranous walls.

We have to study, in the *tunica vaginalis:* 1. Its *interior*. 2. The *enveloping membranes* which form the external wall, and to which we give the common name of *scrotum*.

Interior.—The serous sac constituting the tunica vaginalis is vertically elongated, and slightly inclined downwards, inwards, and backwards. Its *inferior extremity*, forming the bottom, or *cul-de-sac*, is pear-shaped, and lodges the testicle and its epididymis. Its *middle portion*, contracted into a narrow canal, contains the spermatic cord. The *superior extremity*, or *entrance*, is open, to maintain communication with the abdominal cavity; through it pass the spermatic vessels and vas deferens.[1]

As has been said, the peritoneum forms this vaginal sac. As in the abdomen, it is divisible into two layers—*parietal* and *visceral*. The latter (*tunica vaginalis propria*) covers the testicle and the cord; while the former (*tunica vaginalis communis*, or *reflexa*) lines the innermost of the membranous coverings which serve as a wall to the tunica vaginalis. These two layers are made continuous by a serous frænum, analogous to the mesentery which sustains the floating colon; like it, it is formed by the junction of the two layers. Flat, elongated from above to below, and extending vertically from one end of the sac to the other, this frænum is attached, by its upper border, behind the spermatic cord; its lower extremity passes over the epididymis, and from it on to the testicle; above, it is continued into the abdominal cavity, in accompanying the different vessels composing the cord.

(A small quantity of serous fluid is usually present in the tunica vaginalis. When in excess it gives rise to hydrocele.)

Enveloping Membranes.—The stratified layers that form the external walls

[1] If this opening be abnormally dilated, a loop of intestine may enter it, and lie alongside the testicle in the sac, constituting inguinal hernia.

of this vaginal membrane—and which are generally described in anatomical treatises, with the two serous layers, as the *envelopes of the testicle*—are four in number. Reckoning them from within to without, they are the *fibrous tunic*, *cremaster muscle*, *dartos*, and *scrotum*.

Fibrous Tunic (*infundibuliform fascia*).—This forms the most complete covering to the tunica vaginalis, extending, as it does, over the whole surface of the parietal serous layer, to which it is closely adherent. Very thin, especially at the points corresponding to the cremaster, this membrane is continuous, around the upper inguinal ring, with the transversalis fascia, of which it is only a dependency ; its external face is in relation with the cremaster and dartos.

Cremaster (or *cremasteric fascia*).—This muscle is usually described as an envelope of the testicle, by the name of *tunica erythroïdes*. In the domesticated animals it is a bright-red band, attached, above, to the inner or peritoneal surface of the ilio-lumbar aponeurosis ; it descends into the inguinal canal, envelops outwardly only the middle portion of the tunica vaginalis, and expands below on the *cul-de-sac*, where its fibres terminate by small tendons, which are inserted into the external surface of the infundibuliform fascia. Therefore it is that the envelope the cremaster forms is very incomplete—the greater portion of the testicle, and the inner side of the cord, being left unprotected by this muscular tunic. It is in relation, inwardly, with the fibrous membrane, to which it is united by a plentiful connective tissue ; externally, it is related to the posterior wall of the inguinal canal and the dartos. (It is a connective dependency of the internal oblique muscle.)

It is the contraction of the cremaster that causes the sudden ascent of the testicle.

Dartos.—The tissue composing this tunic is contractile ; it is constituted by a mixture of elastic tissue and unstriped muscular fibres. The dartoïc tunic does not reach the inguinal canal ; consequently, it does not cover that part of the tunica vaginalis. It forms a pouch below the inguinal ring, and is spread from around the margin of this on to the neighbouring parts, to which it adheres somewhat closely ; it is prolonged, gradually thinning, into the sheath of the penis, and even on to the penis itself, and to the tunica abdominalis, as well as between the thighs. The two pouches it forms are quite independent of each other, never becoming confounded, though placed in contact on the mesial line to form a double partition (*septum scroti*), the leaves of which are separated above for the passage of the penis. The dartos is in relation, inwardly, with the fibrous and erythroid tunics, from which it is isolated by an abundance of lamellar connective tissue,[1] which is very condensed towards the globus major epididymis, and forms at this point a kind of cord that passes from the fibrous tunic to the dartos, adhering strongly to each. Externally, the dartos is covered by the scrotum.

This tunic determines the vermicular movements of which the scrotum is the seat. It wrinkles the skin of the scrotum, and makes it firm and dense, thus aiding the cremaster in raising the testicle. When it is not in a state of contraction, the skin of the scrotum is smooth and even, and the testicle pendulous.

Scrotum.—The different membranes enumerated above are double, one being for each tunica vaginalis ; but the scrotum constitutes a single pouch, enveloping the two testicles at the same time. It is merely the portion of skin

[1] The testicle is disengaged by tearing through this tissue, in castration by the "covered operation."

covering this region, and is thin, and so closely adherent to the dartos that it can only with difficulty be separated from it. It is covered by very short fine hair, and the extremely numerous sebaceous follicles in its texture secrete an unctuous matter that renders its surface soft to the touch.

(There are also numerous sudoriparous glands, and these, with the sebaceous glands, keep the skin soft and pliable, and modify the effects of friction during progression. On its surface it shows a *raphé* or seam in the middle, which is a trace of its primary division, and corresponds to the median septum separating the testicles.)

2. The Testicles (Figs. 517, 518, 519, 521).

External Conformation.—Each testicle is oval in shape, flattened on both sides, lodged in the *cul-de-sac* of the tunica vaginalis,[1] and suspended at the extremity of the spermatic cord. The description of this organ is extremely simple; it offers for study *two faces*, *two borders*, and *two extremities.*

The *faces*, *external* and *internal*, are smooth and round. The *inferior border* is convex and free, like the faces; the *superior*, almost straight, is related to the epididymis, which adheres to it by its head and tail.

Means of Attachment.—The testicle is freely pendent in the lower part of the tunica vaginalis, where it cannot readily be displaced, because of the narrowness of the space containing it. It is suspended, by its upper border, to the *testicular* or *spermatic cord:*[2] a thick funiculus contained in the middle portion of the vaginal sheath, and formed by the aggregation of the spermatic vessels with the vas deferens.

This cord is itself sustained in the tunica vaginalis by the frænum that unites the two serous tunics of that cavity.

Structure.—Independently of the serous tunic that covers the exterior of the testicle, there enter into its structure a *fibrous membrane*, *tissue proper*, and *vessels* and *nerves*. The excretory duct will be studied separately.

Fibrous Membrane.—This membrane, designated the *tunica albuginea*, forms a strong, resisting, thick shell around the testicle, and its texture is channeled by sinuous spaces which lodge the large spermatic vessels. It is covered by the visceral layer of the tunica vaginalis, to which it closely adheres; its inner face sends thin septa into the proper substance of the gland, which divide the latter into the spermatic lobules. Towards the upper border of the testicle, and in front, the tunica albuginea is slightly thickened; this part is named the *corpus Higmorianum* (or *mediastinum testis*), and at this point the seminal ducts pass through it to reach the epididymis.

(This membrane is dense and inelastic, being composed of white fibrous tissue interlacing in every direction.)

Tissue proper.—The proper substance of the testicle resembles a greyish-yellow pulp, contained in the tunic albuginea; it is divided by the prolongations which that tunic sends into its interior, into small, conical, distinct lobules (*lobuli*

[1] One or both testicles may be retained in the constricted portion of the tunica vaginalis, or remain in the abdomen; animals in which this occurs are named *monorchids* or *cryptorchids.* The absence of one or two testicles (*anorchidism*) is extremely rare. *Ectopiæ of the testicles* is the designation applied to these organs when they are found elsewhere than in the ordinary situation.

[2] In surgical anatomy, there is sometimes included in the spermatic cord the middle portion of the tunica vaginalis and all its envelopes—the serous, fibrous, and erythroid tunics.

testis), independent of each other. These lobules vary in number, from two to three hundred, and all have the same organization, each being constituted by two or three extremely convoluted filiform tubuli, about from one to two yards in length. These tubes—the *tubuli seminiferi*—anastomose frequently with each other, are intertwined, and can be unwound like a ball of thread. One of their extremities terminates in a *cul-de-sac*; the other is detached from the lobule, and enters a central system of excretory ducts which will be referred to immediately.

When we cut through a testicle vertically and lengthways, so as to divide the *corpus Highmorianum* into two lateral portions, there is seen in its substance a whitish framework, sometimes not very apparent, which, curving upwards at both extremities, extends from that body to the posterior extremity of the testicle

Fig. 517.

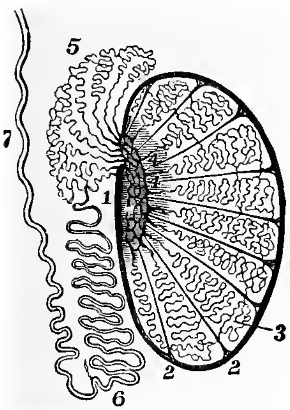
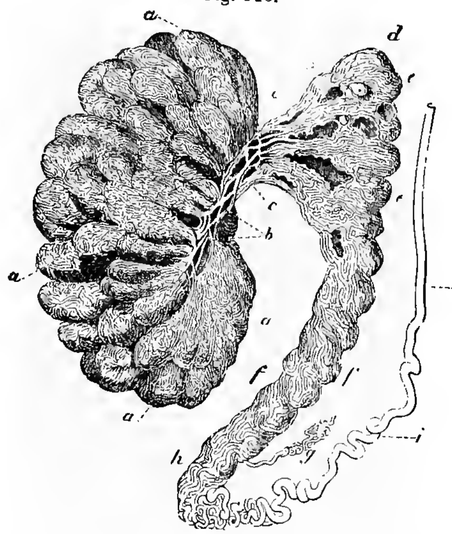


DIAGRAM OF THE TESTICLE.

1, Mediastinum testis, containing the rete testis; 2, 2, trabeculi; 3, one of the lobules; 4, 4, vasa recta; 5, globus major; 6, globus minor; 7, vas deferens.

Fig. 518.



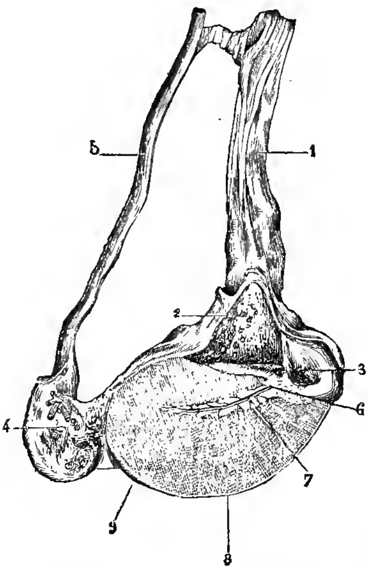
A TESTICLE INJECTED WITH MERCURY.

a, *a*, Lobules formed of seminiferous tubes; *b*, rete testis; *c*, vasa efferentia; *d*, flexures of the efferent vessels passing into the head, *e*, *e*, of the epididymis; *f*, body of the epididymis; *g*, appendix; *h*, cauda; *i*, vas deferens.

(Fig. 518), where it disappears; from this are given off a large number of fibrillæ (*trabeculæ testis*), which diverge in all directions. A mercurial injection by the vas deferens, shows that this part of the testicle is chiefly formed by a ramifying system of rectilinear canals with very thin walls, which open into each other, and unite, on reaching the corpus Highmori, into about twenty principal trunks, from ·3 mm. to ·6 mm. in diameter. These are named the *straight canaliculi* (*vasa* or *tubuli recti*), to distinguish them from the convoluted tubuli (*tubuli contorti*); they receive the latter at their exit from the lobules, are surrounded by numerous blood-vessels, and are sustained by the fibrous septa of the tunica albuginea, which appear to converge towards the point they occupy. At the corpus Highmorianum, the *tubuli recti* pass through that body, forming in its texture an anastomosing network—the *rete testis*—and are continued into the epididymis as the *efferent canals* (*vasa efferentia*).

The *seminiferous tubes* in the lobules are from ·20 mm. to ·25 mm. in diameter. Their walls are composed of two membranes—an internal, which is thin, amorphous, and formed of cells joined border to border as in an endothelium; and an external, thicker, lamellar, and containing nuclei. The walls are lined by a stratified epithelium, which is constantly undergoing evolution in the adult. The external layer is named the basal epithelium. It contains two kinds of cells: ordinary, indifferent cells, named the "cells of Sertoli;" and thin, round, granular cells (*spermatogonia*) mixed with these. The latter are the male ova of Robin, and it is they alone which exhibit the phenomena of spermatogenesis. Before the manifestation of this process, the male ova proliferate, join the cells of Sertoli, and form on the face of each of these elegant radial series.

Fig. 519.



VERTICAL SECTION OF THE TESTICLE (HORSE'S), PASSING THROUGH THE CORPUS HIGHMORIANUM.

1 Spermatic cord, with its serous covering; 2, sections of the flexuous vessels of the cord; 3, head of the epididymis, or globus major; 4, tail of the epididymis, or globus minor; 5, vas deferens; 6, corpus Highmorianum; 7, rete testis; 8, tunica albuginea sending prolongations from its inner face, and which divide the testicle into lobules, 9, surface of the tunica albuginea.

Spermatogenesis is the name given to the epithelial evolution which leads to the formation of *spermatozoids*. In spermatogenesis, there are two periods: 1. The period of the proliferation of the tubular epithelium resulting in the production of the spermatoblasts. 2. The period of differentiation, in which the spermatoblasts are transformed into spermatozoids. This change involves the nucleus of the spermatoblast, which becomes the head of the spermatozoid; then the protoplasm, from which is produced the tail of the spermatozoid.

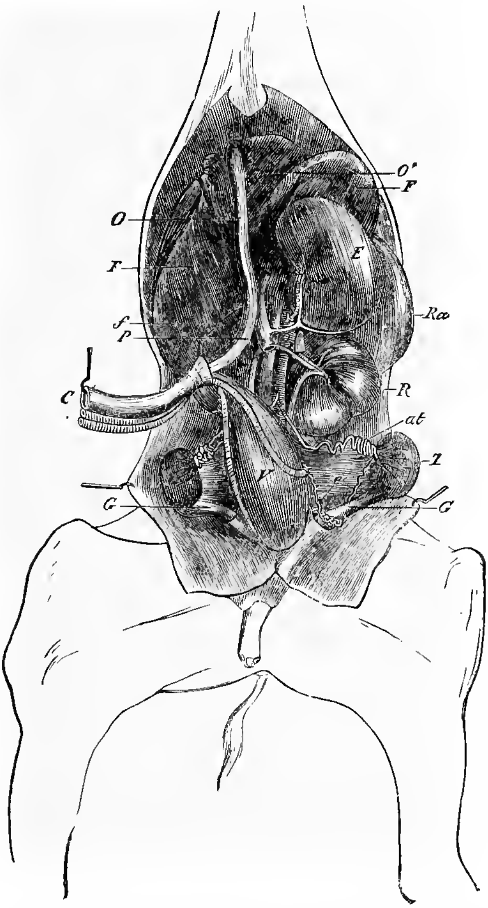
Between the seminiferous tubules is a stroma composed of somewhat peculiar connective tissue, in which are numerous cells filled with yellowish granules. Blood-vessels and lymphatics course through this stroma.

Vessels and nerves.—The blood is carried to the testicle by the *spermatic artery*, which is almost exclusively appropriated to it; this vessel, after describing a great number of very remarkable flexions, enters the upper border of the gland, a little behind the epididymis. It does not immediately plunge into its substance, however, but passes within the texture of the tunica albuginea, along the borders of the testicle, and forms a complete circle around it. From this circle it sends off divisions, which spread over the sides of the organ, detaching fine arterial ramifications that penetrate its proper tissue in accompanying the inter-lobular septa. (There is generally described a *tunica vasculosa*, which forms one of the coverings of the testicle. This, in reality, is not a distinct coat, but merely the fine ramifications of the spermatic artery spreading beneath the tunica albuginea, and held together by delicate connective tissue.)

The *veins* are very voluminous and frequently varicose; they comport themselves like the arteries, and unite in a single trunk that enters the posterior vena cava, near the renal veins. (On the cord, in addition to their sometimes varicose condition, the spermatic veins have been observed to form a network, named the *pampiniform plexus.*)

The *lymphatics* are most numerous beneath the serous layer and the tunica

Fig. 520.



THE INTERNAL GENITO-URINARY ORGANS, WITH THE STOMACH, LIVER, AND SPLEEN, IN THE FŒTUS OF A MARE

R, Left kidney; *V*, bladder; *T*, testicle; *at*, spermatic artery; *G*, gubernaculum testis; *e*, epididymis (the letter is placed in the centre of the serous layer which suspends the testicle and spermatic vessels from the sublumbar region, and after the descent of the gland, forms the frænum between the two layers in the vaginal sheath); *E*, stomach; *F*, liver; *f*, lobus Spigelii; *P*, vena portæ; *C*, umbilical cord; *O*, umbilical vein; *O'*, intra-hepatic course of that vein, indicated by a double dotted line.

albuginea. They commence by lacunæ in the interstitial connective tissue, and form a very rich network, in the meshes of which are seminiferous tubules. They pass into the network of the tunica albuginea, and thence they follow the spermatic cord to terminate in the sublumbar glands.

The *nerves* of the testicle are derived from the sympathetic (and pass from the abdomen with the blood-vessels) ; they form a small particular plexus around the artery. (The nerves pierce the membrana propria of the tubuli seminiferi, and end in a more or less pyramidal mass of protoplasm, in which lie clear elliptical nuclei. The ends of the fibres, therefore, lie in close proximity to the outer layer of the secreting cells.)

DEVELOPMENT.—In the fœtus, at an early age, the testicle floats in the abdominal cavity, being suspended from the sublumbar region, near the flank, by a wide peritoneal fold, at the anterior border of which are the spermatic vessels (Fig. 520, *e*) ; the tunica vaginalis is not yet present. The mechanism of the formation of this is very simple, and easy to understand. The visceral layer of the tunica vaginalis, which envelops the testicle and the cord, being already formed, as well as the serous frænum that establishes continuity between this and the parietal layer in the adult animal, it only remains to explain how nature proceeds to construct the vaginal sac in which the gland is afterwards contained.

We have remarked that to the posterior extremity of the testicle is attached a thick round funicle, the other end of which passes into the internal inguinal ring ; this is enveloped by the peritoneum, and fixed to the posterior border of the serous layer that suspends the testicle. This funicle is the *gubernaculum testis*, and is continuous by its inguinal extremity with the dartos, the structure of which it apparently shares, and which alone acts as the scrotal sac to it. The serous layer covering it has on its outer adherent face the cremasteric muscle, which is attached to the ilio-lumbar aponeurosis in the vicinity of the inguinal ring, enters the serous tube formed by the peritoneal envelope of the gubernaculum, and advances by its terminal extremity to near the testicle. To this organ is due the principal share in the formation of the vaginal pouch.

When the progress of development in the fœtus pushes the testicle towards the inguinal region, the gubernaculum acts as a guide, as its picturesque name sufficiently indicates. It is the first to descend into the inguinal opening, drawing the testicle after it. But in performing this movement it also carries along its peritoneal covering, which gradually leaves it to become related, by its adherent face, to the walls of the inguinal canal ; and thus this membrane becomes reflected, just as would a sock everted or turned down from the leg to the foot, the latter being supposed to represent the testicle.

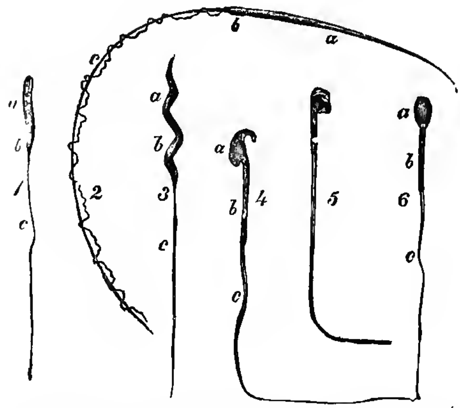
The parietal layer of the vaginal sac is, then, nothing more than the serous tube that, in the fœtus, enveloped the gubernaculum testis while it was in the abdomen, and which is reversed on the testicle and cord after their descent into the scrotum, the cremasteric muscle on its adherent face having become external.

In all species, the descent of the testicle commences before birth : in the Bovidæ it is even completed in the early months of intra-uterine existence. In Solipeds, however, the testicle most frequently remains in the inguinal canal until the animal is from six to ten months old.

FUNCTION.—The testicles secrete the spermatic (or seminal) fluid. *Pure semen*, such as is derived from these glands, is a white, viscid, odourless, and slightly alkaline fluid. It contains a small quantity of liquid matter (*liquor seminis*), in which is an innumerable mass of *spermatozoids*. After the semen has passed through the genital canals, it is made much more watery by the addition of the fluids secreted by the walls of these excretory ducts, or by the glands annexed to them.

The *spermatozoa*, *zoösperma*, *spermatozoïdes*, or *spermatic filaments*, are little elongated bodies from $\frac{1}{600}$ to $\frac{1}{800}$ of a line in length. They have a pyriform, flattened, or lancet-shaped *head*, and a filiform *tail* terminating in a point; this tail is often furnished at its origin with an enlargement, or unilateral or bilateral alæ. Their form is slightly modified during their course through the excretory ducts. (In the different species, though possessing certain fixed characters, the spermatozoa yet offer some curious diversities. Some of these are well exhibited in the annexed representations of these particles, found in the semen of very dissimilar animals.)

Fig. 521.



1, Spermatozoon of the frog; 2, of the triton; 3, of the finch; 4, of the field-mouse; 5, of the hedge-hog; 6, sheep. *a*, Head with nucleus; *b*, body; *c*, tail.

The spermatozoa move by undulations of the tail (Grohe attributes the motion to the contractile protoplasm contained in the head); they can traverse ·004 m. in a minute. Their movements persist for several days in the genital organs of the female; they are suddenly arrested by water, acids, and the electric spark; on the contrary, they are animated by alkaline fluids. (The movements cease when the spermatozoa are exposed to a temperature of 120° Fahrenheit.) These bodies are developed in the cells of the tubuli seminiferi by a modification of their contents. Their development has been already described above.

Excretory Apparatus of the Semen.

1. The Epididymis and Deferent Canal (Figs. 368, 517, 518, 519).

Epididymis.—The organ thus named commences the excretory canal of the testicle. It is a body elongated from before to behind, placed against the upper border, and a little to the outside, of the testicle. It has a *middle portion* and *two extremities*.

The *middle* is contracted, flat on both sides, and free outwardly; it is related, inwardly, to the spermatic vessels and the testicle, to which it is attached by a very short serous layer. The *extremities* are expanded, and adhere closely to the testicle. The *anterior*—the largest—is named the *head of the epididymis*, or *globus major*. The *posterior*, the *tail of the epididymis*, or *globus minor*, is more detached from the testicle, and is curved upwards to be continued by the deferent canal (*vas deferens*).

Structure.—The epididymis results from the union of from twelve to twenty small tubes—the *efferent ducts*—which, arising from the *rete testis*, open together, at a variable distance, into the globus major. Towards the globus minor there is only one duct, which is more voluminous and less flexuous, and ends by becoming detached from the posterior lobe of the epididymis to constitute the vas deferens.

The organization of the walls of these ducts is not the same throughout. Thus, in the *efferent ducts* it comprises a simple ciliated epithelium, resting on a proper amorphous membrane, which again is placed on unstriped circular fibre, lying on a thin fibrous tunic ; while beyond, there is observed a stratified ciliated epithelium, a proper membrane, two layers of unstriped fibres—circular and longitudinal—and also a fibrous tunic. The thickness of the muscular layers increases from before to behind.

The epididymis is enveloped by a fibrous membrane and the tunica vaginalis propria. It receives its arteries and nerves from the same sources as the testicle.

Vas Deferens.—This duct is about the thickness of a goose-quill, and is at first flexuous, then straight. It lies parallel with, but behind and to the inner side of, the spermatic vessels, as far as the opening of the internal ring ; passing through this opening, it enters the pelvic cavity, and crosses obliquely the ureter and obliterated cord of the umbilical artery. It is then inflected backwards above the bladder, suddenly dilates (*bulbous portion*), and is prolonged as far as the neck of that reservoir, where it terminates, after having penetrated beneath the prostate gland by a sudden constriction, at the origin of which, and outwardly, the vesicula seminalis opens, and is continued by the ejaculatory ducts.

It may, therefore, be divided into four portions—a *testicular*, *funicular*, *inginual*, and *pelvic*.

The vas deferens is sustained in the vaginal canal by a very short serous fold —a dependency of the frænum—the two layers of which envelop the spermatic vessels, within and behind which this duct is situated. In the abdominal cavity, it is fixed by the prolougation of this serous duplicature. Its dilated or pelvic portion is in contact, superiorly, with the vesiculæ seminales, and is finally united to its dilated homologue of the opposite side—which it has been gradually approaching—by means of a triangular peritoneal fold, that comprises between its two layers a small club-shaped cavity—the *prostatic utricle*, which will be alluded to again.

The calibre of the vas deferens is very small in its vaginal and abdominal portious, but is greater towards the pelvic dilatation, where the wall of the duct offer a well-marked areolated disposition (*ampullæ*).

Structure.—The vas deferens is formed, internally, by a very fine *mucous membrane* covered with cylindrical epithelium, and to this is added, externally, a *contractile* and a *fibrous tunic*. The contractile layer is formed of three planes of smooth muscular fibres ; the deep and superficial planes have longitudinal, and the middle circular fibres. It is, proportionately, very thick at the dilated portion of the duct, and it is to its great density that the vas deferens owes its consistence as a hard, rigid cord. The mucous membrane of the pelvic dilatation offers a large surface, being inflected into all the depressions, but it has no follicles ; the cells of its epithelium have special granules which give a dark colour to the membrane.

2. The Vesiculæ Seminales and Ejaculatory Ducts (Fig. 522).

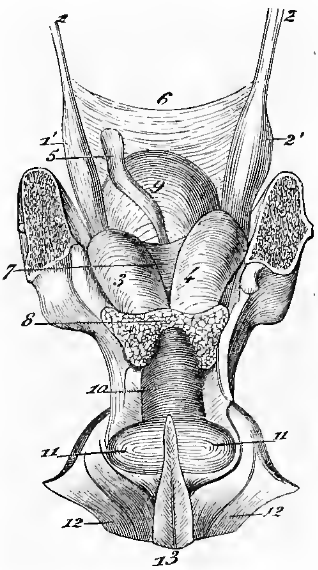
The *vesiculæ seminales* are two oval pouches, the volume of which varies with their contents ; they are placed in the pelvic cavity, above the bladder and the vas deferens.

Each vesicula has a *middle portion* and *two extremities*. The *middle portion* is enveloped by a loose abundant connective tissue, and is in relation with the rectum above, and below with the bladder and vas deferens.

The *anterior extremity* is the largest, and forms a rounded *cul-de-sac*, covered in almost the same manner as the bladder by the peritoneum, which at this point furnishes a very small triangular frænum (the *recto-vesical fold*) that unites the two vesiculæ. The *posterior extremity* tapers to a narrow neck or gullet, which passes beneath the prostate gland, and joins at a very acute angle the terminal extremity of the vas deferens, to constitute the ejaculatory duct.

The walls of this pouch are composed of three membranes: an internal *mucous*, a middle *muscular*, and an external *fibrous*. The *mucous* layer is continuous with that of the ejaculatory ducts, and is very thin, delicate, and follicular. It shows numerous folds, which disappear with distension of the duct. The *middle layer* evidently belongs to the class of muscular membranes. At the bottom of its *cul-de-sac* it gives off several fasciculi, which radiate on the external surface of the peritoneum. (In addition to these, the vesiculæ and vasa deferentia have a muscular covering with fibres arranged in longitudinal and transverse direction, the latter being the most superficial. This muscular layer, being continuous over the vesiculæ seminales and vas deferens, when it contracts will compress and shorten these; consequently, it has been named the *compressor vesiculæ et ductus seminalis*. The fibrous coat of the vesiculæ is merely condensed connective tissue.) The mucus and muscular coats are supplied with blood by the vesico-prostatic artery (*inferior vesical*); their nerves are derived from the pelvic plexus.

Fig. 522.



SUPERIOR VIEW OF THE PELVIC PORTION OF THE VASA DEFERENTIA, VESICULÆ SEMINALES, PROSTATE GLAND, COWPER'S GLANDS, AND THE INTRA-PELVIC PORTION OF THE URETHRA.

1, Left vas deferens; 1′, its pelvic dilatation; 2, 2, the same on the right side; 3, 4, vesiculæ seminales; 5, the third vesicula; 6, serous layer uniting the vasa deferentia; 7, that comprised between the two vesiculæ; 8, prostate gland; 9, bladder seen through the serous fold of the vasa deferentia; 10, membranous or intra-pelvic portion of the urethral canal, covered by Wilson's muscle; 11, 11, Cowper's glands enveloped by that muscle; 12, 12, ischio-cavernosus muscle; 13, accelerator urinæ muscle.

The richness in glands of the mucous membrane of the vesiculæ seminales, has led several anatomists to consider them as organs of secretion, and not as reservoirs for the semen. But the large cavity that each forms, appears to demonstrate that they serve as reservoirs and secretory organs at the same time. Their fluid is added to the semen, as is the secretion of the prostate and Cowper's glands.

The *ejaculatory duct* is very short, and succeeds the narrow canal of the vesicula after the latter opens into the vas deferens. The two ducts pass between the prostate gland and urethra, and, after a brief course, terminate in the latter, on the side of the *verumontanum*—a tubercle which will be noticed presently.

Near to, and in front of this tubercle, is a third very small orifice—the opening of the third pouch included between the serous duplicatures joining the vasa deferentia. (This is the *sinus pocularis* or *utriculus prostatio*, the *protometra*, or *vesicula seminalis tertia* or *media* of Gurlt.) Improperly designated the *third vesicular*, or *masculine uterus* (Weber), this pouch (sometimes double) secretes a fluid which is thrown into the urethra.[1] (This third vesicula is present in all the domesticated animals.)

The ejaculatory ducts may become obliterated ; then the secretion of the vesiculæ seminales accumulates in their interior, and gradually distends them until they attain enormous dimensions. We found, in a Gelding, a vesicula which was nearly as large as the bladder ; it contained a brownish, adhesive fluid, holding in suspension epithelial cells and free nuclei.

(The vesiculæ seminales, in addition to their own secretion, receive the semen conveyed by the spermatic ducts, and keep it in reserve until copulation ; when the contraction of its muscular apparatus expels it into the ejaculatory ducts, and from these into the urethral canal.)

3. The Urethra.

The *urethra* is a canal with membranous and erectile walls, commencing at the neck of the bladder, and terminating at the free extremity of the penis.

Course.—When followed from its origin to its termination, it is seen to proceed at first horizontally backwards, then bend downwards at the ischial arch to leave the cavity of the pelvis, placing itself between the two roots of the corpus cavernosum, and passing forward in the channel formed at the lower border of these, until it arrives at the head (*glans*) of the penis, where it terminates by forming a small (cylindrical) prolongation, named the *urethral tube.* In its track, the urethra is divided into two very distinct portions : the *intra-pelvic*—the shortest, and the *extra-pelvic*—the most extensive, and which is supported by the corpora cavernosa. The latter division, being alone enveloped by the erectile tissue that enters into the formation of the urethral walls, has been also named the *spongy portion*, the first being designated the *membranous* (and *prostatic*) *portion.*

Interior.—Internally, this canal has not the same width throughout. Very constricted at its origin, towards the neck of the bladder, it expands somewhat suddenly at the prostate gland ; its dilatation, improperly named in Man the *cul-de-sac of the bulb* (*bulbous portion*), or, better, the *ventriculus*, extends to its curve over the ischial arch, where it gradually contracts. After this it preserves the same reduced dimensions throughout its course, though these dimensions may be increased during the passage of the urine or semen. There is, however, behind the urethral tube a small oval dilatation, named the *fossa navicularis* (Fig. 524). Smooth throughout its extra-pelvic portion, the inner surface of the urethra offers, near the neck of the bladder, and on its upper wall, the excretory orifices of the prostate gland, which form two lateral lines of minute perforated tubercles. Between these two lines is found the *urethral ridge* or *verumontanum* (*caput gallinaginus*), a little eminence elongated from before to behind, on the sides of which the ejaculatory ducts open. Behind this are the excretory orifices of Cowper's glands.

Relations.—The intra-pelvic portion of the urethra is in relation, above, with the prostate, which adheres closely to it, and with the rectum, to which it is

[1] In some Asses, we have found this pouch bifurcated at its anterior extremity, and therefore bearing a distant resemblance to the female uterus.

(Though Chauveau states that the protometra is improperly named the *male uterus*, it would appear, nevertheless, that the designation is correct ; as this pouch is not a gland in the ordinary sense of the term, and is certainly the rudiment of the duct which develops into the uterus in the female.)

united by the abundant loose connective tissue in this part of the pelvis; below, it lies on the internal obturator muscle; laterally, it is related to the muscles and ligamentous or aponeurotic expansions that close in the sides of the pelvis. Outside the pelvic cavity, the urethra is united in the most intimate manner to the corpora cavernosa, which embrace its anterior border. By its posterior border, it is related to the suspensory ligament of the penis.

STRUCTURE.—The urethra is composed of: 1. *Mucous membrane.* 2. *An erectile envelope.* 3. *Muscles.* 4. *Vessels and nerves.* 5. The *perineal aponeuroses*, which are in immediate relations with this canal.

1. **Mucous Membrane.**—This is rather delicate, and forms the lining of the canal. It is continuous, posteriorly, with that of the bladder, and in front with the integument enveloping the head (*glans*) of the penis; it is also prolonged into the excretory ducts of the glands annexed to the urethra, and the ejaculatory ducts. It has longitudinal folds, and is always in contact with itself, except during the passage of urine or semen; it has scarcely any papillæ, only a few being found near the anterior extremity of the canal; and its tissue is very rich in elastic fibres.

The epithelium of this membrane is stratified and cylindrical, but at the portion furnished with papillæ it becomes pavemental.

2. **Erectile Envelope.**—This envelope, lying outside the mucous membrane, does not cover the intra-pelvic portion of the canal. It commences a little above the ischial contour, behind Cowper's glands, by a very thick bulging portion, named the *bulb of the urethra.* In front, it terminates by another bulbous enlargement, into which the anterior extremities of the corpora cavernosa enter, named the *head of the penis* (*glans penis*).

The tissue composing this envelope has the same organization as other erectile apparatuses, being a network of communicating cavities separated by elastic septa, the latter showing in their structure some contractile elements (see Corpora Cavernosa).

3. **Muscles.**—Behind the prostate gland, the mucous membrane of the urethra is covered by a fleshy layer of circular fibres, forming a sphincter. Another muscular envelope, constituting the *bulbo-cavernous* or *accelerator urinæ* muscle, also covers the erectile tissue of the urethra, accompanying it to near the glans, where it gradually disappears. To these two principal muscles of the urethra are added two pairs of secondary fasciculi—the *compressor of Cowper's glands* and the *transversus perinæi.* The following is a *résumé* description of the muscular apparatus:—

a. Urethral sphincter.[1]—This may be described as a single muscle composed of two portions—an inferior and a superior. Both are formed by transverse fibres thrown over the membranous portion of the urethra, and both—the superior and inferior—are united at their extremities, which are not attached to the walls of the pelvis. Behind, the superior fibres are mixed with those of the *compressor of Cowper's glands.*

b. Accelerator urinæ.—Composed of transverse fibres encircling the urethra

[1] Up to the present, this organ has been described in books on Veterinary Anatomy as *Wilson's muscle.* In a work entitled *Recherches sur l'Anatomie comparée du Perinée*, published in Professor Robin's journal, Paulet rightly objects to this designation, which perpetuates an error of interpretation. We adopt this opinion, not only with regard to this muscle, but also the ischio-urethral, which, with him, we more exactly designate as the *compressor of Cowper's glands.*

from the ischial arch to the free extremity of the penis, this will also be studied as a single organ, separated into two lateral portions by a median raphé passing along the whole posterior face of the urethra. The fibres pass from this raphé to the right and left, enter the furrow of the corpora cavernosa, and reach the upper surface of the urethra, where they advance towards each other, but do not join in the middle line; so that the circle formed by this muscle is necessarily incomplete.

c. *Compressor muscle of Cowper's glands.*—This muscle is composed of two layers of fibres—a superior and an inferior—confounded on the periphery of Cowper's glands. The superior layer is continuous, it may be said, with the upper part of the urethral sphincter. The inferior layer is attached, posteriorly, by some aponeurotic fibres to the ischial arch.

d. *Transversus perinæi.*—This is a very thin ribbon-like fasciculus, often scarcely distinguishable from the ischio-anal muscle (*retractor ani*). It extends transversely from the ischial tuberosity—to which it is attached through the medium of the sacro-sciatic ligament—to the mesial line of the perinæum, where its fibres—confounded with those of its homologue on the opposite side—appear to be inserted in the accelerator urinæ muscle at its origin.

e. *Action of the urethral muscles.*—1. The *urethral sphincter*, when it contracts, compresses between its two layers the membranous portion of the urethra. It is a veritable sphincter, and opposes the escape of the urine; when the semen is thrown from the vesiculæ seminales into the urethra, it also prevents that fluid entering the bladder, by permitting the accelerator to empty, from before to behind, the initial dilatation of that canal. 2. The *accelerator urinæ* is correctly named, from the part it plays in ejecting the semen from the urethra—it being the chief agent in this act. 3. The *compressor of Cowper's glands* pulls back the membranous portion of the urethra, along with Cowper's glands, and acts as a compressor to these. 4. The *transversus perinæi* dilates the bulbous portion of the urethra, by drawing it out laterally.

4. Vessels and Nerves.—The urethra is supplied with blood by the bulbo-urethral arteries and the two pairs of arteries—the *dorsals of the penis*. Voluminous *veins*—frequently varicose, and satellites of the arteries—carry it away. The *lymphatics* form a very rich plexus beneath the mucous membrane; their trunks pass to the inguinal, and some to the sublumbar, glands. The *nerve*-filaments are from the internal pudic and great sympathetic.

5. Aponeuroses of the Perinæum.—In the perinæal region, the urethra is covered by two superposed fibrous layers.

The *superficial aponeurosis* is fibro-elastic, and appears to arise from the inner surface of the thighs, where it is mixed with the dartos; it covers the perinæum, and its fibres, becoming disassociated, disappear on the sides of the sphincter ani. This membrane is in relation, externally, with the skin, and, internally, with the deep aponeurosis. On the middle of its external face, it receives the insertion of a muscular fasciculus, which is detached from the sphincter.

The *deep* or *perinæal aponeurosis*, formed of white inelastic fibrous tissue, adheres to the preceding by its outer face, and to the accelerator urinæ and ischio-cavernous muscles by its inner face. Above, it is lost around the termination of the rectum; below, it expands between the thighs. To the right and left, it insinuates itself between the erector penis and semimembranosus muscles, to be attached to the ischiatic tuberosity; it is prolonged in the pelvic cavity between the bladder and rectum, where it limits two independent spaces: 1. A superior—defecatory—space. 2. An inferior—genito-urinary—space. Below it is confounded with the fibrous envelope of the penis.

4. The Glands annexed to the Urethra.

A. **Prostate** (Fig. 522, 8).—This single and symmetrical gland is situated at the commencement of the urethra, and lies across the neck of the bladder. A constriction in the middle divides it into two voluminous lateral lobes, inclining slightly forward. Its upper face corresponds to the rectum, through the medium of the connective tissue at the bottom of the pelvic cavity. Its inferior face, moulded on the neck of the bladder, embraces it above and laterally, and is closely attached to it; it covers the terminal extremity of the vas deferens and ejaculatory ducts, and the neck of the vesiculæ seminales.

Structure.—The tissue composing this gland forms a number of communicating cells, which are larger in the Ass than the Horse; in these is collected a quantity of viscid fluid (*succus prostaticus*) secreted by their walls, and which is ejected into the urethra by the two rows of orifices arranged on the sides of the verumontanum. These communicating cells are nothing more than conglomerate glands, which are distributed in a stroma of connective tissue and unstriped muscular fibres. The epithelium of the glandular *culs-de-sac* is formed of two layers of cells; those of the excretory ducts are ciliated.

B. **Cowper's Glands.**—In Veterinary anatomy, these are frequently named the *small prostates*. They are two globular bodies, denser in texture than the prostate gland, but otherwise the same in organization, except in their epithelium, which is cylindrical. They are situated on each side of the urethra, in the perinæal region, above the ischial arch, and are completely enveloped by a somewhat thick fleshy covering, formed by the fibres of the compressor muscle (Fig. 522, 11).

The fluid they secrete is thrown into the urethral canal by numerous orifices in several rows, near the middle line of the superior plane. It has the same physical properties as that of the prostate, and both are poured into the urethra in abundance immediately before ejaculation; the expulsion of the semen is by this means facilitated.

5. The Corpus Cavernosum.

The *corpus cavernosum* is an erectile body, which forms the base of the penis and supports the urethra; it is situated between the thighs, prolonged beneath the abdomen, attached behind to the ischial arch, and terminates in front by a free extremity, which is received into the erectile enlargement named the glans penis.

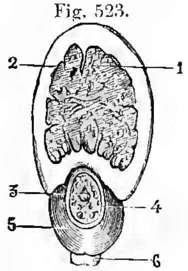
External conformation.—Flattened on both sides, this body offers for study two *lateral faces*, two *borders*, and two *extremities*.

The *faces* are plane, and present no features of interest. The *superior*, or *dorsal border*, is the thickest, and is rounded on both sides. The *inferior* is channeled throughout its extent by a deep furrow which lodges the urethra. The *posterior extremity* is bifurcated, the two branches constituting the *roots* (*corpora* or *crura*) *of the penis;* they are fixed to the ischial arch, one to the right, the other to the left, and are covered by the two *ischio-cavernosus* (*erector penis*) *muscles*—short, thick, and strong masses intersected by numerous tendinous fibres, and partly concealed by the semimembranosus muscles. These erector penis muscles arise from the inferior ischiaic spine, and terminate on the membrane enveloping the crura of the penis, which they cover posteriorly and externally.

The *anterior extremity* of the corpus cavernosum forms a blunt point, and is surrounded by the spongy tissue of the glans.

Mode of attachment of the corpus cavernosum.—The chief attachment is constituted by the insertion of the two crura into the ischiatic arch. There is also a double *suspensory ligament* proceeding from the ischio-pubic symphysis, where it is confounded with the superior attachments of the short adductor of the thigh, and passes to the dorsal border of the corpus cavernosum, a little in front of the point of union of its crura.

Fig. 523.



TRANSVERSE SECTION OF THE PENIS, SHOWING THE RELATIONS OF THE URETHRA WITH THE CORPUS CAVERNOSUM.

1, Erectile tissue of the corpus cavernosum; 2, envelope of ditto; 3, urethral canal; 4, erectile tissue of the urethra; 5, accelerator urinæ; 6, section of the suspensory ligament of the penis.

STRUCTURE.—This erectile organ is composed, externally, of a white, elastic, fibrous envelope, remarkable for its thickness, especially on the dorsum; it gives off, from its inner face, a certain number of lamellar trabeculæ which partition the interior of the cavity it forms. One of these septa (*septum pectiniforme*) is directed vertically from the upper to the lower border, and divides the corpus cavernosum into two lateral portions (*corpora cavernosa*), which would indicate that the crura are not one mass at their point of union, but merely joined to each other. In the Horse, this septum is generally very incomplete, and rarely extends the whole length of the organ.

The lamellar prolongations sustain other elastic and contractile bands, which circumscribe the cavities in which is lodged the essential portion of the erectile tissue. According to Legros, the latter is composed of a network of capillaries interposed between the arterial and venous twigs; this network shows abrupt or regular dilatations of a diameter varying from ·0001 m. to ·0015 m. These successively dilated capillaries have very thin walls, which are adherent to the contractile prolongations of the envelope, and are lined by a very delicate pavement endothelium. In the areolæ of the cavernous tissue, particularly towards the base of the organ, the arteries offer a special arrangement; their walls are very thick, and they soon divide into a bouquet of branches which enter the areolæ, where they terminate either by a *cul-de-sac*, or—which is most frequent—give off small free branches convoluted in a spiral manner. These are the *arteriæ helicinæ* described by Müller and Rouget. (The walls of the cells are composed of white and yellow fibrous tissue, and unstriped muscular fibres. The cells themselves are in reality venous sinuses. Kölliker found a minute artery to proceed from each of the cæcal terminations of the helicine arteries, and terminate, like the other capillaries, in the veins. The dilated vessels have been regarded by some anatomists as only vascular loops. The cells, during the erection of the penis, are distended with blood.)

The *arteries* of the corpus cavernosum and dorsales penis pass into the erectile structure, and supply this organ with blood. The collateral *veins* of these arteries arise near the surface. The *nerves* are from the internal pudic and great sympathetic.

6. The Penis.

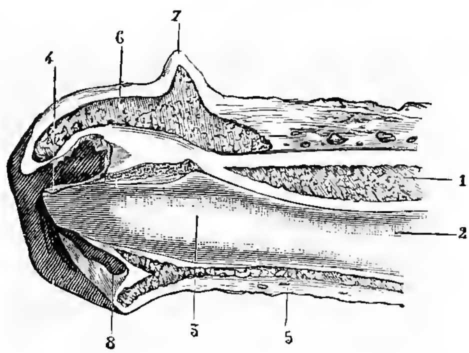
The *penis* is the male organ of copulation, and results from the union of the corpus cavernosum and the spongy portion of the urethra. These parts have already been described; so it now remains to consider the organ in its entirety.

The penis commences at the ischial arch, passes between the thighs and the two dartoid sacs containing the testicles, and is prolonged beneath the belly, where it terminates in a free extremity.

All the portion comprised between the ischial arch and the scrotum is maintained and deeply covered by the surrounding textures, and is named the *fixed portion* of the penis. The remainder of the organ—its anterior moiety—is, on the contrary, its *free portion*, as it forms a detached appendage sustained by a cutaneous fold—the *sheath* (or *prepuce*).

The Fixed Portion occupies the perinæal region and that between the thighs, where it is enveloped by the arteries, veins, and nerves already known, as well as by a large quantity of connective tissue (and the skin).

Fig. 524.



LONGITUDINAL SECTION OF THE FREE EXTREMITY OF THE HORSE'S PENIS IN A RELAXED STATE.

1, Erectile tissue of the corpus cavernosum; 2, urethra; 3, fossa navicularis; 4, urethral tube; 5, erectile tissue of the urethra; 6, ditto of the glans; 7, corona glandis; 8, urethral sinus.

The Free Portion is lodged in the prepuce during the inactive condition of the organ, but protrudes from it when in a state of erection. It is then seen to be covered by a smooth, unctuous, tegumentary membrane with numerous papillæ, and of variable colour, though most frequently it is black or variegated. Its *base* presents a slight circular enlargement, due to the accumulation, beneath the mucous membrane, of a small annular mass of elastic and contractile tissue. Its *extremity* or *glans* is also a circular enlargement, limited behind by a salient ridge —the *corona glandis*—which is notched inferiorly, and at the moment of ejaculation assumes a considerable development, its shape being then not unlike the rose of a watering-can. This enlargement has for its basis the terminal expansion of the urethral erectile tissue, and presents on its anterior face: 1. In the centre, a rounded prominence due to the anterior point of the corpus cavernosum. 2. Beneath this, the *urethral tube* encircled by a fossa. 3. At the bottom of the fossa, and below the urethra, the orifice of a double cavity—the *urethral sinus*, which widens at the bottom, and in which accumulates sebaceous matter that sometimes becomes so hard as to prevent the flow of the urine, by compressing the tube. 4. Inferiorly, the *suburethral notch.*

The dermis covering the extremity of the penis is rich in nerves which, according to Kraüse, have round dilatations which he designates as "terminal genital corpuscles."

To complete the description of the penis, there only remain to be described: 1. Two *suspensory* and *retractile ligaments* which concur, with the natural elasticity of the fibrous envelope of the corpus cavernosum, to return the organ to its ordinary position when the phenomenon of erection has ceased. 2. The tegumentary fold, or sheath, which envelops the free portion of the penis when in its ordinary state of repose.

A. **Suspensory and Retractile Ligaments of the Penis.**—Two in number, these ligaments arise from the lower face of the sacrum, descend as flat bands in front of the sphincter ani, between the retractor muscle of the anus and the rectum, to which they give numerous short fasciculi from their posterior border; they then unite at the mesial line, below the anal opening, thus forming around the terminal extremity of the rectum a real suspensory ring. Lying together, and intimately united, they are continued on the accelerator urinæ, which they follow at the raphé, and are eventually lost in its texture, near the free extremity of the penis.

These cords are composed of unstriped muscular fibres.

B. **Prepuce.**—The prepuce, or sheath, is a cavity formed by a fold of the abdominal skin, and lodges the free portion of the penis; it is entirely effaced at the moment of erection, when the copulatory organ is lengthened and enlarged. The skin at the opening of the prepuce enters its cavity, and, on arriving at the free portion of the penis, forms a circular *cul-de-sac* in becoming reflected over the organ, which it envelops.

This lining integument of the prepuce is fine, and is very irregularly plicated; it is destitute of hair, and holds a middle place, with regard to organization, between the skin and mucous membranes. It contains in, or beneath, its substance a considerable number of sebaceous or *præputial* glands that secrete an unctuous fatty matter (exhaling a peculiar odour, and dark grey in colour—the *smegma præputii*), which is spread over the free surface of the membrane.

Above, the inner integument of the sheath is applied to the tunica abdominalis. Below, and on each side, the cutaneous fold constituting this cavity contains between its layers an expansion of yellow elastic fibrous tissue, the lateral portions of which, attached to the abdominal tunic, are named the *suspensory ligaments of the* prepuce.

In the **Ass**, there exists, near the entrance to the prepuce, and on each side, a small tubercle which may be looked upon as a rudimentary teat of the female.

(The prepuce protects the penis, and sustains it when in a flaccid state. In certain Horses, a gurgling sound is produced in trotting, from the air brusquely entering and leaving this sheath.)

Differential Characters in the Male Genital Organs of the other Animals.

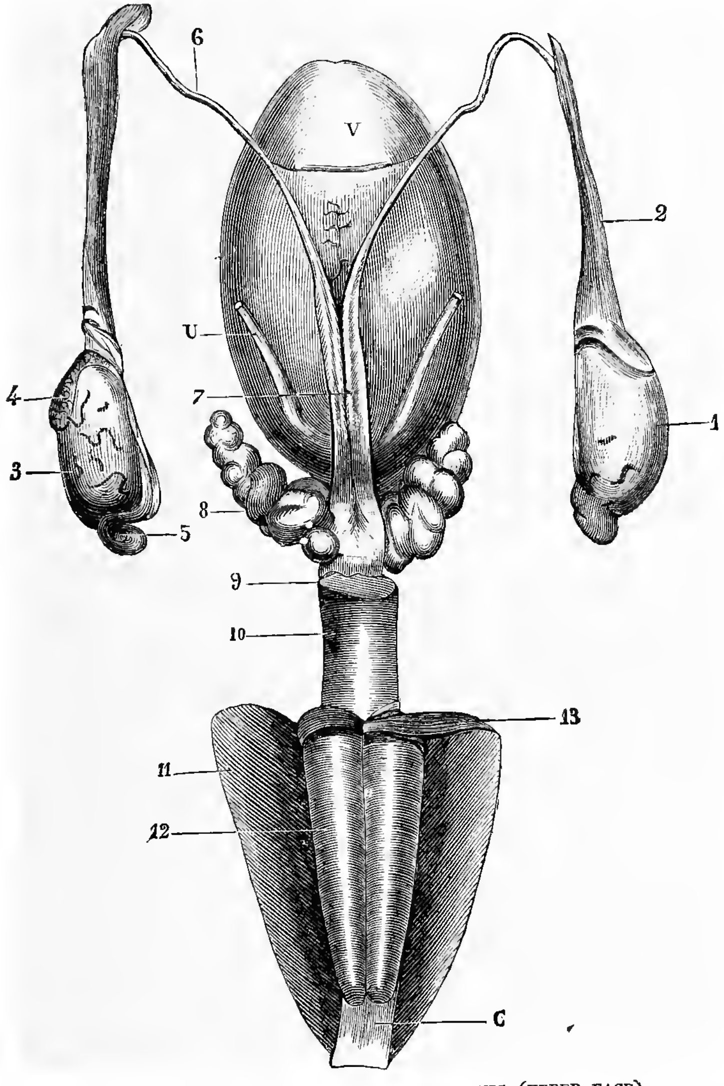
Ruminants.—*Vaginal sheath.*—Gouhaux has remarked that, in the Bull, the internal inguinal ring is very small when compared with that usually seen in the Horse. It is situated nearly at the point of union between the two originating branches of the sartorius muscle.

Testicles.—In these animals the testicles are very voluminous, oval, and vertically elongated. They, with their envelopes, form a pendant mass that occupies the inguinal region. The scrotum is always of a pale colour. In the interior of the testicle, the corpus Highmorianum and the *rete testis* are very marked. (The proper tissue is yellow, and the septa formed by the prolongations of the tunica albuginea are not very distinctly seen.)

Epididymis.—Vas deferens.—The head of the epididymis is wide and flat, and partly covers the anterior border of the testicle. The middle portion, smaller than in Solipeds, represents a narrow cord lying outside the posterior border of the seminal gland. The tail is a little free appendage, inflected inwards and upwards to become continuous with the vas deferens. The latter is dilated, as in the Horse, when it arrives above the bladder, and lies beside the duct of the opposite side. The two, thus joined, increase from before to behind, leave the neck of the bladder in passing above the vesiculæ seminales, then go beneath the prostate, and terminate in the urethra—on the summit of a ridge—by two elliptical orifices.

Vesiculæ seminales.—In the **Bull,** the vesiculæ seminales have not the same appearance as

Fig. 525.



INTERNAL GENITAL ORGANS OF A YOUNG BULL (UPPER FACE).

V, Bladder; U, ureter; C, penis enveloped by the corpus cavernosum. 1, Testicle in its fibrous envelope; 2, cremaster; 3, testicle exposed; 4, head of the epididymis; 5, tail of the epididymis, 6, vas deferens; 7, dilatation of the vasa deferens; 8, vesiculæ seminalis; 9, prostate; 10, intra-pelvic portion of the urethra surrounded by its sphincter; 11, ischio-urethral muscle; 12, accelerator urinæ; 13, transversus perinæi.

in the Horse, and they have not so large a cavity in their interior. They are two elongated masses, lobulated on their surface, yellow in colour, and possessing quite a glandular aspect. They have sometimes been designated the lateral prostates. They are composed of aciniform glands, enclosed in a mass of connective tissue and unstriped fibres; they open into a common central canal, which terminates in the vas deferens.

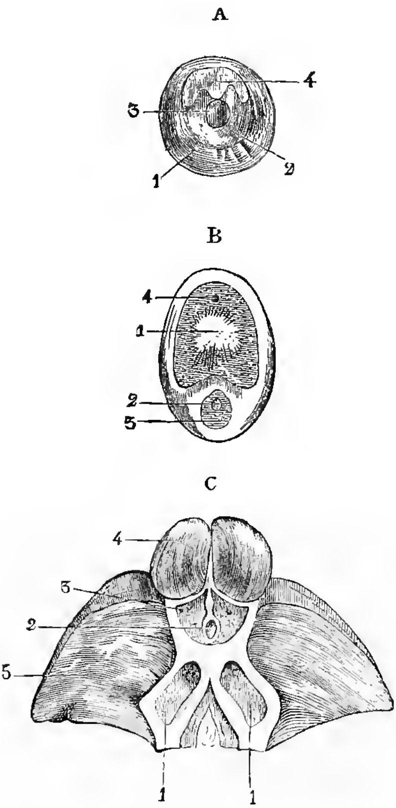
Urethra.—This canal is inflected like the letter S. Its diameter regularly diminishes from its commencement to its termination, which is not provided with a urethral tube, as in Solipeds. Internally it presents: 1. Immediately beyond the neck of the bladder, a short, but very salient *verumontanum*, which divides into two mucous columns that gradually subside posteriorly. 2. Towards the ischial arch, a valve the free border of which—directed downwards—covers a *cul-de-sac* from about three-fourths to one inch deep.

The structure of the urethra is also different. The walls of the *membranous portion* are thicker than in the Horse; they have a layer of erectile tissue, and a sphincter muscle, very thick below and laterally, the fibres of which are inserted in the middle of the upper surface, into an aponeurotic raphé.

At the ischial arch, when the canal bends downwards, the spongy tissue becomes more abundant to form the *bulb of the urethra;* but the prominence at this point is chiefly due to the *accelerator urinæ*, as is shown in Fig. 526, C 4. This muscle is extremely powerful, but it soon ceases beneath the ischial arch. The *transversus perinæi* is as strong as in Solipeds.

Glands annexed to the urethra.—*Cowper's glands* are absent. The prostate gland is not voluminous, and forms, at the commencement of the urethra, a little transverse yellow, bilobate mass, beneath which pass the vasa deferentia; it also lies beneath the sphincter muscle, and is prolonged for some distance on the membranous portion of the urethra.

Fig. 526.



SECTIONS OF THE URETHRA OF THE OX AT DIFFERENT POINTS.

A, *Intra-pelvic portion:* 1, Urethral sphincter; 2, erectile tissue; 3, urethral canal; 4, prostate gland. B, *The middle of the penis:* 1, Fibrous cord of the corpus cavernosum; 2, urethral canal; 3, its erectile tissue; 4, envelope of the corpus cavernosum. C, *At the crura of the penis:* 1, 1, Crura of the corpus cavernosum; 2, urethral canal; 3, its erectile tissue; 4, accelerator urinæ; 5, erector penis muscle.

Penis.—In the **Bull**, the penis is long and thin, and carried well forward beneath the belly. It is enclosed at the perinæum in an aponeurotic sheath, which is covered by the ischio-tibial muscles. This sheath is double, its superficial layer being continuous with the dartos, and it has the same physical characters; the deep layer is thin, white, and inelastic.

In front of the pubis, the penis describes two successive curves—the *S of the penis*—the first with its convexity forwards, the second backwards. It is at the second curve that the *suspensory ligaments* join the penis, and continue along its sides to its extremity.

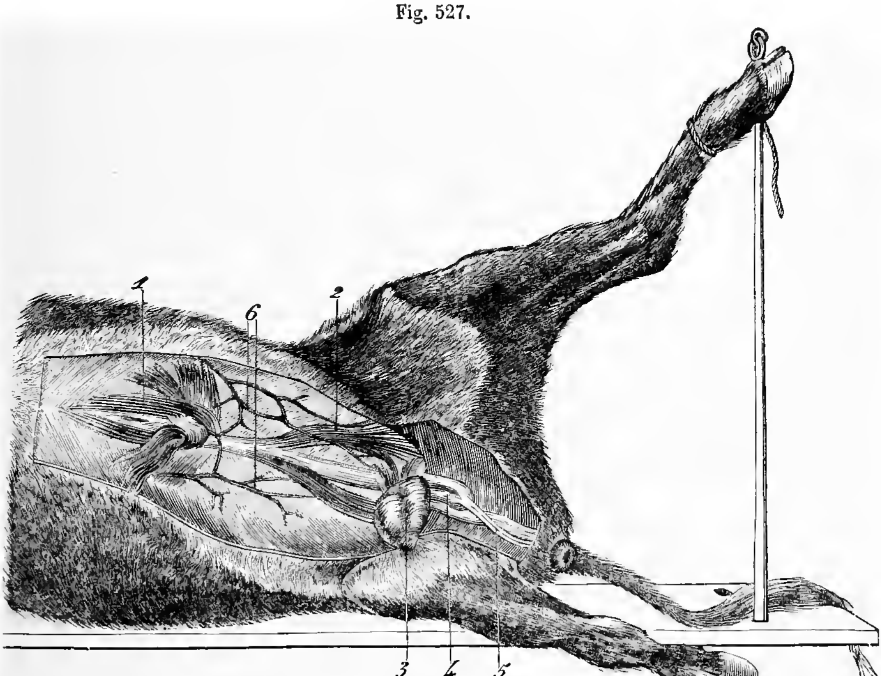
The free portion of the organ—very tapering—is covered by a fine, papillated, very sensitive, rose-coloured mucous membrane.

It is lodged in a narrow prepuce that advances much more forward beneath the abdomen than in Solipeds, and has at its opening a bunch of long stiff hairs. This cutaneous sheath is moved by four subcutaneous muscles: two posterior or *retractors* (Fig. 527, 2) which draw the sheath backwards, and concur in exposing the penis at the moments of its erection; and two anterior or *protractor* muscles (Fig. 527, 1) which carry the prepuce forward to its former position. The latter are found in the Cow, and do not appear to be of any use.

The two constituent portions of the copulatory organ are not joined in the same manner as in Solipeds, the channel for the lodgment of the urethra being transformed into a complete canal, by a narrow layer of the fibrous envelope of the corpus cavernosum. The latter is little developed, and presents, internally, a longitudinal fibrous cord; it is not much dilated during erection. In this act, the penis is elongated by the straightening out of its curvatures, rather than by any real lengthenings; when erection ceases, the organ is retracted into the preputial cavity by the contraction of the suspensory ligaments, which reform its double inflection behind the scrotum.

In the **Ram,** the disposition of the testicles and vasa deferentia is somewhat similar. The membranous portion of the urethra has no prostate, but quite posteriorly it has two small Cowper's glands, the upper face of which is covered by a red muscular layer that leaves the origin of the bulbous portion and is lost on this surface. The muscles are disposed as in the Bull. But the spongy portion of the urethra is not enveloped by the corpus cavernosum, which is channeled, as in Solipeds, by a furrow that lodges the urethra. The head of the penis is remarkable for two lateral folds, disposed like wings at the base of the glans. One of these is only slightly developed, so that the head of the penis looks asymmetrical. The

Fig. 527.



PENIS AND MUSCLES OF THE PREPUCE OF THE BULL.

1, Protractor muscle of the prepuce; 2, retractor of ditto; 3, testicles in the scrotum; 4, the *S* of the penis; 5, suspensory ligaments of the penis attached to the second curve; 6, subcutaneous abdominal vein.

urethra is also prolonged by a vermiform appendix from 1 to $1\frac{1}{2}$ inches long. (In the Ram, the extremity of the urethra has the form of a narrow cylinder curved backwards, its opening being a longitudinal slit. In Ruminants, towards the extremity of the prepuce are small teats; these, in the **He-goat,** are sometimes glandular, and secrete a fluid analogous to milk.)

PIG.—The *testicles* of this animal are round, and placed in the perinæal region. The scrotum is narrow, and but little detached: the pouches of which it is composed appearing simply as two hemispherical prominences on the surface of the perinæum. There is nothing particular to be remarked in the *epididymis* and *vas deferens;* (the *tail* of the first is very voluminous; the latter has no pelvic dilatation.)

The *vesiculæ seminales,* with regard to disposition, are intermediate between those of the Horse and Ox. Their walls are thick and very glandular, and their interior is diverticulated. (They are, proportionately, very large, and, in structure, closely resemble those of Ruminants;

indeed, in these animals they rather appear to be organs for the secretion of a milky liquid that is mixed with the semen, than reservoirs for the fecundating material, as that fluid never contains any spermatozoa.) There are two *prostates:* one disposed as in the Ox; the other placed across the neck of the bladder, as in Solipeds. The *penis* resembles that of Ruminants, except in the absence of the muscles of the prepuce; it has also a particular preputial sheath, which has been studied by Lacauchie. (When flaccid, the penis of the Pig is twisted in a spiral manner at the extremity. The prepuce is narrow, and longer than in Ruminants. At the upper part of its opening is the special pouch mentioned by Chauveau, and which is formed by a fold of the skin. It opens into the prepuce, and secretes, in the Boar, an unctuous fluid, possessing a particularly disagreeable smell, and which is mixed with the urine. The odour of the secretion even taints the flesh of this creature.)

CARNIVORA.—The testicles of the **Cat** are formed like, and placed in the samo situation as, those of the Pig; those of the **Dog** are more oval, and are pendent.

The Carnivora have no *vesiculæ seminales.* The *prostate gland* surrounds the neck of the bladder; it is of a yellow colour, concave on its upper surface, and divided into two lateral lobes on its lower face. *Cowper's glands* are absent in the **Dog**; they exist in the **Cat** (in which they are very small, and excrete their secretion by separate efferent canals). The *urethra* (in its pelvic portion) is very long; towards the ischial arch it shows an enlargement or *bulb*, though this is less, proportionately, than in the Ox; the accelerator urinæ muscle is continued for a longer distance around it. (The spongy portion is thinner in the Cat than in the Dog.)

"In the **Dog**, the *penis* is long and pointed. The posterior half is constituted by the corpus cavernosum, which is little developed, and has not a complete middle septum. The anterior moiety has for its base a bone, found in several other mammifers, which is intended to favour the introduction of the penis into the genital organs of the female.

"The *penien* or *penial* bone is elongated, conical, and incurvated, so as to constitute a furrow inferiorly, in which is lodged the urethra when it leaves the fibrous channel of the corpus cavernosum; its apex, anteriorly, partly forms the point of the penis; its base is intimately united to the anterior portion of the corpus cavernosum; the median septum, which is very dense, is fixed in this bone, as is the fibrous envelope which mixes with its periosteum.

"The penial bone almost entirely constitutes the base of all that portion of the penis included within the sheath; in addition, this part possesses two distinct *erectile enlargements*—an *anterior* and *posterior.* The first is analogous to that of the glans penis of the Horse, and is formed by an expansion of the erectile tissue of the urethra; club-shaped at its anterior base, it has there a point suddenly bent downwards, beneath which is the urethral orifice; posteriorly it is thin, and partially covers the other erectile mass. The latter is supplementary; it begins at the base of the free portion of the penis, where the integument of the sheath is folded in a circular manner around it. From 1 to $1\frac{1}{2}$ inches long, it embraces the upper border and sides of the bone; pyramidal in shape, its base, which is posterior, is from $\frac{3}{4}$ to $1\frac{1}{4}$ inches thick; in front, it thins away beneath the erectile tissue of the head.

"Such are the two erectile masses, the summits of which overlap, so that the free portion of the penis, bulging in front, and still more so behind, is narrowest in the middle. Although contiguous, these two vascular dilatations are independent of each other; the posterior has, likewise, no communication with the corpus cavernosum, and possesses two particular veins which pass backward in the lateral groove. Each is erected separately during copulation, when they assume a large size; the great volume of the posterior enlargement prolongs the duration of this act, until flaccidity ensues. This peculiarity is a consequence of the absence of the seminal reservoirs (the vesiculæ seminales).

"In the **Dog**, two small *muscles* are found which appear to be destined to elevate the penis and direct it during its introduction into the sexual parts of the female, as its erection is always feeble. These are two fasciculi which proceed from the crura of the penis, and pass forward to unite in a common tendon implanted on the dorsal border of the organ; they thus resemble the cord of a bow.

"The subpenial muscular cords exist as in the other animals. The *prepuce* is narrow and long, and, as in the didactyles, has *protractor* muscles; the integument is thin and rose-coloured, like that covering the free portion of the penis.

"In the **Cat**, the penis is short, and directed backwards; but in a state of erection it is inclined forwards for copulation. Its free portion presents some peculiarities. It is conical, and its summit, near which is pierced the urethral opening, has for its basis a small incomplete penial bone, that encloses a layer of erectile tissue—an expansion of that of the urethra. This free portion is covered by an integument studded with somewhat rigid papillæ directed backwards, and capable of being made erect during copulation. These points, which are met with in nearly all the feline species, are analogous to the hairs, scales, strong spines, and even the cartilaginous saws, of certain other animals, and which appear to be related to the degree of sensitiveness of the female sexual organs" (A. Lavocat).

Glands annexed to the genital organs.—Chatin has studied the anal glands in the Dog. These are two oval masses about half an inch long, situated on the sides of the rectum, at its termination. They are covered by a tunic of striped muscular fibres, and are formed by acini measuring from ·05 mm. to ·07 mm. and ·10 mm., which are lined by polyhedral cells of ·009 mm. In the centre of the gland is a small reservoir that communicates by a short and dilatable canal with the definitive excretory duct; this opens on the margin of the anus by an opening partially concealed by a fold of skin. The secretion is brownish and fœtid.

In the young Dog, the general disposition is the same, the constituent anatomical elements only being a little smaller.

In the Cat, the disposition of the glands differs but little from what is observed in the Dog.

RODENTS.—*Vaginal sheath.*—In the **Rabbit**, the internal inguinal ring is very elongated, and placed horizontally below the inferior face of the pelvis; the bottom of the scrotal cavity —pyriform—hangs beneath the ischium.

The *cremaster muscle* completely envelops the fibrous tunic; the dartos is only represented by a few scattered fibres; the *scrotum* is covered by long and fine hairs.

Testicles.—These are ellipsoid in shape and relatively voluminous. They are lodged sometimes in the scrotum, at other times in the abdomen; in the latter case, they are attached to the bottom of the scrotal sac by a *gubernaculum testis.* The seminiferous ducts are very developed, and easily separated.

Epididymis—Vas deferens.—The head of the epididymis is flattened, and the tail forms a conical and very much detached appendix. The vas deferens is isolated from the vessels of the testicle in the scrotal cavity, so as to form two spermatic cords. When the deferent canals arrive above the bladder, they remain free and without dilatation, and open at different places in the urethral canal, beneath a small valve.

Vesicula seminalis.—There is only one—the *male uterus*—with thin walls, lying on the cervix and part of the upper face of the bladder. This vesiculus terminates, posteriorly, by a very short canal placed in the prostate, and opening on the surface of the urethra, above a valve situated between those which cover the termination of the deferent canals.

Urethra.—This canal is very dilatable, and has thin walls exclusively membranous in its terminal moiety. It has no erectile enlargement at its extremity.

Glands.—The prostate of the **Rabbit** is oblong and voluminous; it lies across the commencement of the urethra, but is prolonged forward in such a manner as to cover the deferent ducts and a great part of the vesicula seminalis. There are two Cowper's glands, which are oval and enveloped in the sphincter of the urethra.

Penis.—When this organ is relaxed, it has a horizontal direction, parallel to the coccygeal region. Its total length is about 8 inches—4 for the fixed, and 4 for the free portion. The dorsal border is thin, and the other border has a groove in which is lodged the urethra.

The penis is contained in a prepuce or sheath, the outer surface of which is garnished with longer hairs than those on the neighbouring parts; it is also provided with a retractor muscle, which is fixed around the penis.

The other muscles that act on the penis are: I. Two enormous *erectores penis.* 2. A rudimentary *accelerator urinæ* that seems to disappear towards the extremity of the organ. 3. A long, flat muscle, the fibres of which are directed obliquely downwards and backwards, commencing, as they do, on the borders of the coccyx, and terminating on the sides of the deeper portion of the corpus cavernosum; in contracting, this muscle draws the penis from the inferior face of the coccygeal vertebræ. 4. A muscle formed of two bellies, attached to the ischiatic arch, and prolonged behind by a tendon which is fixed on the dorsum of the penis. This muscle—which we propose to name the *subischio-cavernous* (*suberectores penis*)—plays an important part in copulation. We have observed, while injecting the penis, that the organ in a state of erection is vertical; but this position is unfavourable for sexual intercourse, and then it is that the muscle intervenes, for when it contracts it raises the penis towards the abdomen, and renders coition possible.

Glands annexed to the genital organs.—Below the root of the tail, on each side of the anus and prepuce, are two large shallow cavities lined by white skin, moist and destitute of hair. In the centre of these cavities is a papilla with an opening in its summit; this papilla corresponds to the *anal gland.*

The anal glands are conical, and formed of two little superposed masses—one brown in colour, the other yellow-tinted. They are constituted by a number of glandular acini, that secrete a fatty unctuous matter. At the bottom of these cavities also open the excretory duct of two other undescribed glands. These are situated deeply on each side of the rectum; they are yellow in colour, and are formed—like the preceding—of acini, the cells of which contain much fat. Because of their situation, we have named these the *rectal glands.*

We have also studied the generative organs of the **Leporide**—a new or hybrid species which has been the subject of much discussion; and have remarked that there is a perfect resemblance between these organs in a male Leporide and those of the Rabbit. The testicles found in the abdomen have furnished a fluid rich in very vivacious spermatozoids. These Leporides have, therefore, all that is necessary for reproduction *inter se.*[1]

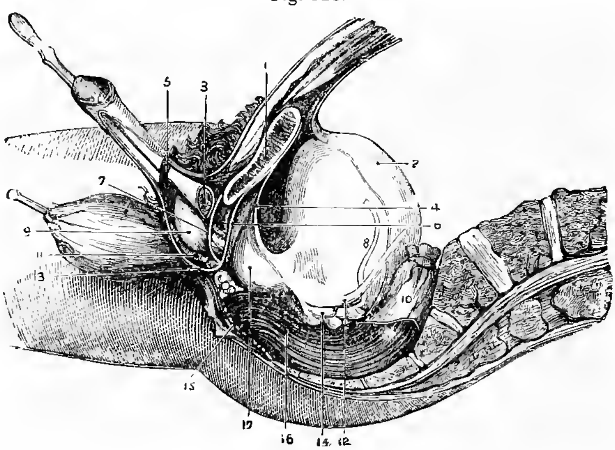
Comparison of the Genital Organs of Man with those of Animals.

Coverings of the testicles.—The *scrotum, dartos, tunica erythryoidea,* and *tunica vaginalis* have the same organization as in Solipeds. The scrotum is rich in sebaceous glands, and the tunica vaginalis is separated by a serous layer from the peritoneal cavity.

Testicles.—These are ovoid, and situated in an oblique direction downwards and inwards; their largest curvature is forwards.

The *epididymis* offers the same arrangement as already noticed, except that the vas

Fig. 528.



SECTION OF PELVIS TO THE LEFT OF THE MEDIAN LINE AT THE PUBES, AND THROUGH THE MIDDLE OF THE SACRUM.

1, Section of left pubic bone; 2, peritoneum on bladder; 3, left crus penis; 4, pelvic fascia forming anterior ligaments of bladder; 5, part of accelerator urinæ; 6, posterior layer of triangular ligament forming the capsule of the prostate; 7, anterior layer of triangular ligament; between 6 and 7 are seen the membranous urethra, deep muscles of urethra (insertion), and Cowper's gland of the left side; 8, vas deferens; 9, bulb of urethra; 10, rectum; 11, cut edges of accelerator urinæ and transversus perinæi; 12, left ureter; 13, reflection of deep layer of superficial fascia round transversus perinæi; 14, left vesicula seminalis; 15, cut edge of levator ani; 16, rectum; 17, prostate gland.

deferens, in being detached from the globus minor, is bent somewhat suddenly to reach the abdominal cavity. There are several diverticuli annexed to the epididymis, named the *pediculated hydatid of Morgagni, non-pediculated hydatid aberrant vessels,* and *corpus innominatum* of Giraldès.

The *hydatid of Morgagni* is a little projection at the head of the epididymis, filled with a serous fluid which is never mixed with the semen. The *non-pediculated hydatid* is a small white mass which rises from the testicle at some distance from the globus major; it has a cavity that communicates with the duct of the epididymis. The *aberrant vessels* are fine flexuous ducts given off from the globus minor, and soon terminate in a *cul-de-sac.* The *corpus innominatum* of Giraldès is a small mass of ramifying tubes included in the connective tissue uniting the globus major to the testicle. All these appendages of the testicle or epididymis, are the remains of the Wolffian body.

[1] For further details, see Arloing, "Etude Comparative sur les organes genitaux du Lièvre, du Lapin et du Leporide," in Robin's *Journal de l'Anatomie et de la Physiologie* for 1868.

Vas deferens.—This is not united to its fellow by a peritoneal fold; it is slightly dilated on arriving at the neck of the bladder, as in the Horse. The vesiculæ seminales are elongated, and lobulated on their surface, as in Ruminants.

Urethra.—This canal has a fixed and a free portion: the first is slightly inclined downwards and forwards; the second is suddenly inflected, and, with the preceding, forms the prepubic angle, which disappears with erection. Its diameter increases a little at the *bulb*, and again at the meatus, to form the *fossa navicularis*. Its erectile envelope forms a considerable enlargement at its commencement—the *bulb*, and this is covered, as in the Ox, by the accelerator urinæ; it also composes another, the *glans*, that constitutes the head of the penis. On its inner surface are some valvular folds, and some depressions—the *lacunæ of Morgagni*, the *verumontanum*—and towards the summit of this a small pouch—the *male uterus* (*sinus pocularis*) which, on a very reduced scale, represents the third vesicula of Solipeds. The muscles of the urethra are the *ischio-cavernosum*, *accelerator urinæ*, *Wilson's muscle*, and the *transversus perinæi—superficial* and *deep*. On emerging from the pelvic cavity, the urethra traverses an aponeurotic membrane named the ligament of Carcassonne.

Corpus cavernosum.—This offers nothing particular in its disposition.

Penis.—This organ is free, and is suspended in front of the pubis. It is enveloped by a fibrous covering—the *superficial fascia*, and a cutaneous cylinder—the *prepuce*. It is attached by two suspensory ligaments: the superficial is elastic, and arises from the linea alba; the deep is inelastic, and is detached from the symphysis pubis and the anterior pillar of the inguinal ring. (It is usual to describe only one ligament—the *ligamentum suspensorium penis*, separating to form two layers which give passage to the dorsal vessels, and nerves of the penis.) The *glans* is separated from the rest of the organ by a constriction designated the *cervix*, and around this the skin forms a (circular) fold—the *prepuce*, which covers the glans more or less completely. It is attached to the middle of its lower face by a thin fold—the *frænum præputii*. The inner surface of the prepuce has a large number of sebaceous glands.

CHAPTER II.

GENITAL ORGANS OF THE FEMALE.

Preparation.—In dissecting the female generative organs, their normal relations should be preserved as much as possible by preparing the subject as in Fig. 536.

1. Place the subject in the first position, carefully removing the skin covering the perinæum and mammæ, the part of the abdominal walls on which the latter rest being left, but the intestines removed according to the usual procedure—a portion of the floating colon being only allowed to remain. Finally, the posterior part of the trunk is cut away by sawing through the spine at the sixteenth dorsal vertebra.

2. Before proceeding to dissect, it is well to inject the bulb of the vagina by the internal pudic artery near its origin, and the uterus and bladder should be inflated.

To inflate the uterus, the following is the procedure: the cervix is made to project through an incision in the middle line of the wall of the vagina; then a straw or inflating tube is introduced into the uterus, and air injected thereby; when sufficiently distended, the cervix is firmly tied with a waxed thread. The bladder is distended by injecting air through a ureter, after closing the urethra; this is done by finding the meatus urinarius with the index finger of the left hand; a hook is then placed on the orifice, which is drawn to the vulva, where two pins are pushed crossways through its mucous membrane and a ligature of waxed thread tied behind these; the points of the pins are cut off, and the parts allowed to resume their natural position.

Finally, the vagina and rectum are slightly distended by means of bundles of tow.

3. When these preparations are completed, one of the posterior limbs is disarticulated; the upper part of the gluteal and posterior crural muscles, as well as a portion of the sacro-sciatic ligament, are cut away. In removing the cellulo-adipose tissue from the pelvic cavity, the neck of the bladder, the rectum, and the vulva are freed; care should be taken not to injure the peritoneal fold that surrounds the middle region of the vagina. The constrictor muscle of the vulva is exposed in removing the skin by shreds with scissors, as was done with the orbicularis muscle of the lips. Afterwards, the portion of the ischium which conceals some portions of the details of the preparation is removed by the saw.

4. When the organs have been studied *in situ*, they are removed—the broad ligaments being preserved—and spread on a table, in order to study their interior.

5. An injection into the galactophorous sinus allows a good idea to be formed of the general disposition of the mammary gland.

These organs resemble those of the male in their general disposition. Thus we find in the female: 1. Two secretory organs—the *ovaries*—analogous to the testicles, in which the germ is elaborated. 2. The *uterine* (*Fallopian*) *tube*, disposed—like the epididymis and vas deferens—as a flexuous canal, through which the ovum passes on leaving the ovary. 3. The *uterus*, a single reservoir formed of two lateral moieties which may be compared to the vesiculæ seminales, as it is there that the germ remains until it is fully developed. 4. The *vagina*, a membranous canal analogous to the urethra, and giving passage to the fœtus after it has been formed in the uterus: this canal, which receives the penis during copulation, also shows, at its exterior opening, the *vulva*—an erectile apparatus—and the *clitoris*, which is nothing more than a rudimentary corpus cavernosum of the male. The female has also certain glands, which, in many species, exist in a rudimentary form in the male: for instance, the mammæ, organs for the secretion of milk, the first nourishment of the young animal.

(The *glands of Duverney*, in the female vagina, seem to be analogous to Cowper's glands in the male, as they are present in the females of all animals where the latter exist in the male, and their secretion appears to be of the same character.)

It may be remarked, after this observation, that the male and female genital apparatuses are constructed on the same type—a circumstance which is most clearly demonstrated at an early period of intra-uterine life, when it is impossible to distinguish the sexes.

1. The Ovaries (Figs. 529, 535).

Situation—Form—Relations.—The *ovaries* (*testes muliebres*)—the essential organs of generation in the female—are two ovoid bodies, smaller than the testicles, though of the same shape, situated in the abdominal cavity,[1] and suspended from the sublumbar region—where they correspond with the intestinal convolutions—a little behind the kidneys. Smooth on the surface, these organs present, in the middle of their upper face, a deep and more or less oblique fissure, resembling the *hilus* of the kidney; this gives attachment to the pavilion of the tube.

Means of attachment.—The ovary floats at the anterior border of the broad ligament; it is also sustained by the vessels that enter it, and by a small cord of unstriped muscular fibres—the *ligament of the ovary*—which attaches it to the uterus.

Structure.—The organization of the ovaries comprises a *serous membrane*, a *tunica albuginea*, *proper tissue*, and the *Graafian vesicles* embedded therein.

Serous membrane.—This is a continuation of the broad ligaments; it covers the whole organ (except at the hilus), adhering closely to the tunica albuginea.

Tunica albuginea.—This is similar to that enveloping the testicle, being a very resisting fibrous covering which sends prolongations into the substance of the ovary.

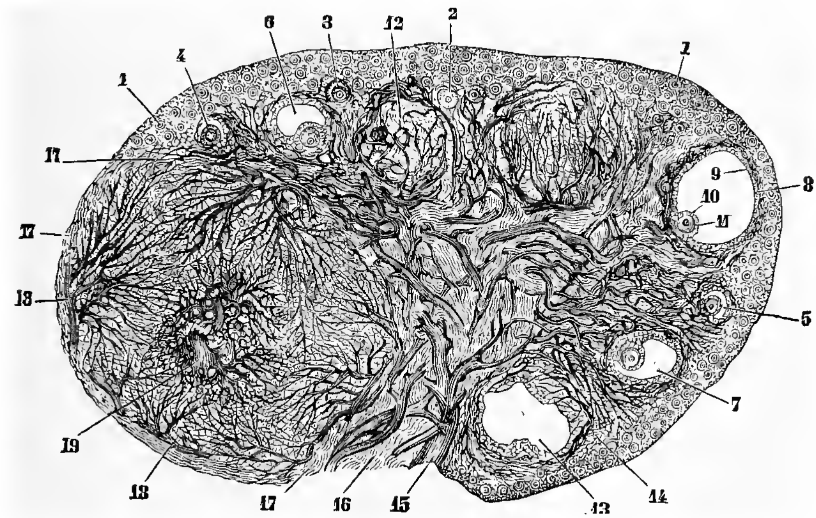
[1] The ovaries sometimes leave this situation. Thus Dupont, of Plazac, has observed them, in four swine, occupying little cavities, analogous to those of the male scrotum, in the perinæal region (*Journal des Vétérinaires du Midi*, December, 1869).

On the surface of this fibrous membrane is found a complete layer of cylindrical cells, which was at one time regarded as a dependency of the peritoneal serous membrane; but it differs widely from it in an anatomical point of view. It is named the *germ-epithelium*, in order to indicate the share it takes in the production of ova during the early period of their development.

Proper tissue.—The proper tissue, or stroma, of the ovary is more consistent than that of the testicle; it is hard, grates on being cut into, and is greyish-red in colour. It is divisible into two layers, distinguishable by their aspect and structure (Fig. 529).

1. The *medullary layer*—that nearest the hilus—is slightly red and spongy;

Fig. 529.



SECTION OF THE OVARY.

1, Cortical vesicles; 2, larger vesicles; 3, vesicles surrounded by the granular membrane; 4, 5, 6, 7, 8, follicles in various stages of development; 9, *membrana granulosa;* 10, ovum; 11, *cumulus proligerus;* 12, non-ruptured follicle surrounded by a capillary network; 13, follicle with its contents partly escaped; 14, stroma of the cortical zone; 15, vessel entering by the hilus of the ovary; 16, stroma of the hilus; 17, external membrane of a *corpus lutea;* 18, arteries of a corpus lutea; 19, its central vein.

it is formed by an interlacing of the connective fibres, unstriped muscular fibres, and a large number of vessels that radiate from the centre towards the periphery.

2. The *cortical layer* has the elements of connective tissue for its base; it is but little vascular, and contains in its substance the *Graafian vesicles* or *follicles* (*ovisacs*), and is consequently often named the *ovigenous layer*. These ovisacs are in various stages of development; the smallest are situated beneath the tunica albuginea, and gradually increase as they lie deeper. When fully developed, they are filled with a transparent, citron-coloured fluid; the ovigenous layer can then no longer contain them, and they protrude more or less from the surface of the ovary.

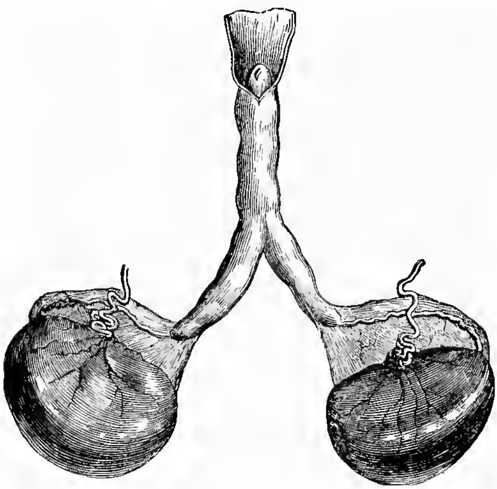
A *Graafian vesicle*, in its perfect state, is composed of an envelope and its contents. The envelope comprises: a *fibrous membrane* (*tunica fibrosa*), which is confounded with the stroma of the ovary, and in it we may recognize two layers, the internal of which is rich in vessels; an *epithelium*, or *membrana* *granulosa*, consisting of round or polygonal granular cells. At the bottom of the ovisac, this epithelium forms a small mass—the *cumulus proligerus* (or *germinal eminence*), in the centre of which is the *ovulum* or egg of the mammal. The *contents* (*liquor folliculi*) is a clear yellow fluid, which becomes red on admixture with blood when the vesicle ruptures.

The *ovulum*, or *ovum*, is a cell about $\frac{1}{100}$ of an inch in diameter, enclosed in the *discus proligerus*, or *cumulus proligerus*. The ovum is invested by a thick membrane—the *zona pellucida* (*membrana vitellina*), formed of cells traversed by radiating canals—the *porous canaliculi* (*ova-tubes*); its granular contents are named the *vitellus*, or *yolk*; and its (vesicular nucleated) nucleus, designated the *germinal vesicle*, or *vesicle of Purkinje*, and lying at a certain point on the zona pellucida, has in its centre a white patch—the *germinal spot*, or *spot of Wagner*.

Balbiani has discovered, alongside the germinal vesicle, another, which he has named *the embryogenic vesicle*.

Vessels and nerves.—The thick, flexuous, arterial divisions are given off by the *utero-ovarian artery*; they ramify in the spaces formed by the tunica albuginea, before reaching the proper tissue by entering the hilus. The *veins*, are of large calibre, and form a very rich network around the gland—the *bulb of the ovary*; they terminate in the vena cava, near the renal veins. The *lymphatics* are very abundant in the medullary substance, and anastomose in a network around the follicles before they pass to the sublumbar glands. The nerves emanate from the small mesenteric plexus.

Fig. 530.



OVARIES, OVIDUCTS, AND UTERUS OF A FŒTUS (EQUINE).

DEVELOPMENT.—The ovary of Solipeds is of great size in the fœtus, being often nearly as large as in the adult animal. Fig. 530 exhibits the proportion between its volume and that of the uterus in a six months' fœtus. It becomes atrophied in aged animals.

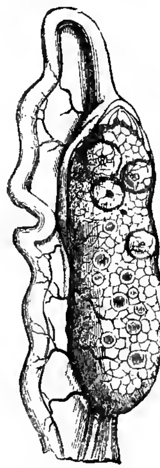
FUNCTIONS.—The productive organs of the germ, or ovum, the ovaries are the *testicles* of the female. They form the ova, and then at certain periods set them at liberty. As the ova are contained in the Graafian vesicles, it is necessary to study: 1. The development of these vesicles. 2. Their rupture, or dehisence. 3. The phenomena occurring in them after rupture.

Development of the Graafian vesicles.—The use of the Graafian vesicles is to remove the ova from the ovary—to prepare their dehiscence; consequently, the development of these vesicles is subordinate to the presence of ova. The latter begin to form among the cells of the germ-epithelium covering the surface of the ovary; then they become deeply embedded in the organ by means of Pflüger's cords, thrown out by the germ-epithelium.

When the ovum is thus buried in the stroma of the ovary, the epithelium accompanying it proliferates and forms two layers—*membrana granulosa*—around them. The surrounding connective tissue, pressed out, accommodates itself to the surface of the mass, and gradually constitutes a spherical shell—the fibrous envelope; then the Graafian vesicle is formed. Soon the two layers of the membrana granulosa separate at one part to form a cavity—the cavity of the vesicle (Fig. 529, 5, 6, 7); but as the separation is not complete, the ovum, encircled by the internal membrane, lies beside the external membrane. As the cavity of the vesicle enlarges, the tissue of the ovary becomes more condensed, and constitutes the fibrous wall, which soon receives a network of vessels.

(This description does not altogether agree with what is taught by physiologists. It would appear that, in the course of development, groups of cylindrical cells grow up from the stroma of the ovary so as to enclose the primordial ova. These may even form tubular-like structures, called by some German writers the ova-tubes. By-and-by, each ovum is surrounded by cells, forming a little round body called the primary follicle, which consists of the ovum and of epithelial cells surrounding it. The formation of this follicle around each ovum is for the purpose, in due time, of ejecting the ovum from the ovary. The size of the follicle increases by the multiplication of epithelium-cells, and soon a space exists round the ovum which is filled with a fluid—the *liquor folliculi*. This liquid may be formed by transudation from the surrounding blood-vessels, and, as some have suggested, by the disintegration and melting away of some of the epithelial cells. We have now a vesicle filled with fluid—the Graafian vesicle—having a diameter of from ·5 to 5 mm. The connective tissue forms the wall of the vesicle. It consists of: 1. A connective tissue covering the *theca folliculi*, which is formed of two strata—an outer of fibrous tissue, *tunica fibrosa;* and an inner, *tunica propria*, rich in cells and vessels. 2. A lining of stratified follicular epithelium, sometimes called the *membrana granulosa*. This lining of epithelium-cells forms a prominence at one side, called the *cumulus ovigerus*, or *discus proligerus*, and the layer surrounding the ovum has been termed the *tunica granulosa*. The space is occupied, as already mentioned, by the liquor folliculi. When the ovum reaches maturity, the Graafian vesicle is full of fluid, and bluges out from the surface of the ovary. It may be mentioned that the primordial ovum is a large round cell, provided with a nucleus and nucleolus; it originates from a single cell of the germ-epithelium.

Fig. 531.



OVARIUM OF THE RABBIT AT THE PERIOD OF ŒSTRUM, SHOWING VARIOUS STAGES OF THE EXTRUSION OF OVA.

In the Cow, at puberty the stroma of the ovary is crowded with follicles so minute, that it has been computed that a cubic inch would contain two hundred millions of them.

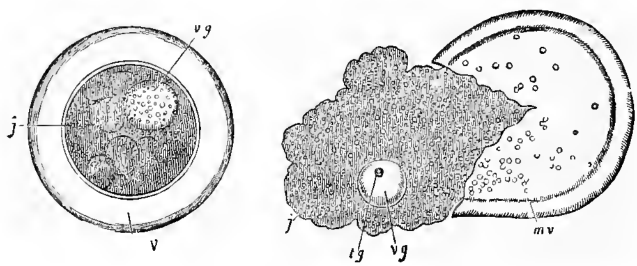
Puberty occurs earlier in small than in large animals. In the Rabbit, Guinea-pig, Rat, and Birds, it is reached during the first year; in the Dog and Cat, in the second year; in the Ox, Horse, and Lion, in the third year; in the Camel, in the fifth year; and in the Elephant, between the twentieth and thirtieth year. Menstruation—or a series of phenomena resembling this function in Woman—occurs in many animals, and is known as the *rut*, or *heat*. Cows and

Sheep rut twice; the Cat, Bitch, and Sow, two or three times; and the Rabbit and Guinea-pig, eight or twelve times, in the course of the year. The condition lasts in the Mare and Cow from two to four days, and in the Sow and Bitch from six to ten days. During this period the females have a peculiar smell, by which the males are attracted, even from long distances.)

Rupture of the Graafian vesicles.—After puberty the ovary becomes vascularized, and a certain number of Graafian vesicles increase in volume. At the period of œstrum, one or more of these, according to the species, participate in the change in the ovary, become vascular and distended, and finish by rupturing and evacuating the discus proligerus and ovum. The latter is received into the Fallopian tube and conveyed towards the uterus.

Corpus luteum.—After the rupture of a Graafian vesicle, its cavity is filled by a clot of blood, which gradually contracts and loses its colour; at the same time the *tunica fibrosa* becomes hypertrophied, and the *membrana granulosa* is wrinkled and transformed into cylindrical epithelium. To this period of progression succeeds one of regression, during which the cylindrical cells become infiltrated with fat and are graduall, absorbed. The term *corpus luteum* is given to the cicatrix resulting from the rupture of a Graafian vesicle.

Fig. 532. Fig. 533.



CONSTITUENT PARTS OF A MAMMALIAN OVUM.

Fig. 532, Entire ovum. Fig. 533, Ovum ruptured, with the contents escaping: *mv*, vitelline membrane; *j*, yolk; *vg*, germinal vesicle; *tg*, germinal spot.

The progress of the phenomena of hypertrophy and regression is much slower when the escape of the ovum has been followed by impregnation; so that we have *false corpora lutea* (those which are independent of pregnancy), and *true corpora lutea*, those of gestation, and which do not disappear until several weeks after parturition. (The true corpora lutea are recognizable, after parturition, as small white or dark-coloured masses—the *corpora albicans vel nigrum.* The yellow colour, to which they owe their name, is due to the infiltration of the cylindrical cells with fat.)

During early life the Graafian follicles are not inert, as has been believed, but are active; only instead of rupturing and throwing their contents into the Fallopian tubes, after attaining their full development they shrivel, become atrophied, and eventually nothing is left of them except a very small yellow body.

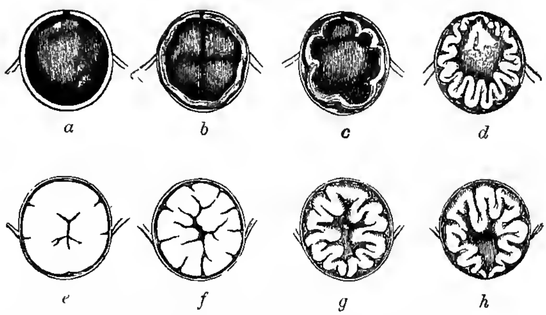
Such are, very briefly, the functions of the ovary.

(Beneath the hilus of the ovary, and between the layers of the broad ligament and the round ligament, is found a small body, usually described as the *parovarium* or *epoophoron*, consisting of a number of fine tubes or tortuous canals with blind extremities lined with ciliated cylindrical epithelium. It is considered as the remains of the Wolffian body—a fœtal structure that forms the epididymis in the male, and has been named the *organ of Rosenmuller* in the female. Chauveau does not mention its existence in the domesticated animals, though Leyh does. There is also the *paroophoron*, likewise found in the broad ligament, and formed of small canals lined with cylindrical cells. This is supposed to be a relic of the urinary portion of the Wolffian body.)

2. The Fallopian or Uterine Tubes, or Oviducts (Fig. 535, 2).

The *Fallopian tube* is a little flexuous canal, lodged in the broad ligament, near its anterior border. It commences at the ovary by a free, expanded extremity—the *pavilion of the tube* (or *ostium abdominale*), and terminates in the *cul-de-sac* of the uterine cornu by opening into it (the *ostium uterinum*). Its

Fig 534.



SUCCESSIVE STAGES IN THE FORMATION OF THE CORPUS LUTEUM IN THE GRAAFIAN FOLLICLE OF A SOW (VERTICAL SECTION).

a, The follicle immediately after the expulsion of the ovum, its cavity being filled with blood, and no ostensible increase of its epithelial lining having yet taken place; at *b*, a thickening of this lining has become apparent; at *c*, it begins to present folds, which are deepened at *d*, and the clot of blood is being absorbed and decolorized; a continuance of the same process, as shown at *e*, *f*, *g*, *h*, forms the *corpus luteum*, with its stellate cicatrix.

canal at the middle is so narrow as scarcely to admit more than a very thin straw, and its calibre is still less towards the uterine extremity; near the ovary, however, it is wide enough for the passage of a thick goose-quill.

The orifice of the *uterine extremity* opens in a small and very hard tubercle. The *ovarian extremity*, in all Mammalia, offers a very remarkable arrangement. It opens into the peritoneal cavity, near the fissure of the ovary, and in the centre of the expansion named the *pavilion of the tube*, which is also designated the *fimbriated extremity* (or *morsus diaboli*). This pavilion is attached to the external side of the ovary, and has a very irregular outline—notched, as it is, into several lancet-shaped, unequal prolongations (*fimbriæ*), which float freely in the abdomen. Here are, then, two important anatomical facts—the discontinuity between a gland and its excretory duct, and the communication of a serous cavity with the exterior.

Structure.—The Fallopian tube is formed of a serous, a muscular, and a mucous tunic. The *serous* (*external*) is furnished by the broad ligament, and is derived from the peritoneum. The *middle* is formed of unstriped muscular fibres, which extend into the pavilion. (They are arranged as *circular*—internal, and *longitudinal*—external fibres, and are continuous with those of the uterus; they are mixed with embryonic nucleated connective tissue.) The *mucous membrane* is arranged in longitudinal folds in the tube, but in the pavilion these folds are radiating; it is covered by a ciliated cylindrical epithelium (the vibrations of the cilia being towards the uterus). (It has very few glands and no villi.) At the margin, or fimbriæ, of the pavilion it suddenly ceases, and is continued by the peritoneum (a serous cyst is frequently found in this situation; at the other extremity the mucous membrane is continuous with that of the uterus).

Functions.—The excretory duct of the ovary, the Fallopian tube seizes the ovum expelled from the Graafian vesicle, and carries it to the uterus. It is therefore necessary that, at the moment of rupture of the vesicle, the fimbriæ should be applied to the ovary, in order to receive the germ and bring it to the abdominal orifice of the tube. The application of the pavilion to the ovary is brought about, either by the contraction of the muscular fibres it contains, or through the distension of the bulb of the ovary. Sometimes this mechanism is insufficient, and the ovum falls into the abdominal cavity, becomes fixed there, and is developed if it has been previously fecundated; this occurrence constitutes the most remarkable variety of extra-uterine gestation.

The oviduct also conveys the seminal fluid of the male to the ovum.

3. The Uterus (Figs. 535, 536).

The *uterus* is a membranous sac to which the ovum is carried, and in which it is developed.

Situation.—It is situated in the abdominal cavity, in the sublumbar region, at the entrance to the pelvic cavity, where its posterior extremity is placed.

Form and relations.—In its posterior moiety, the uterus is a single cylindrical reservoir, slightly flattened above and below; this is the *body* of the uterus. Its anterior moiety is bifid, and gives rise to *two cornua*, which curve upwards.

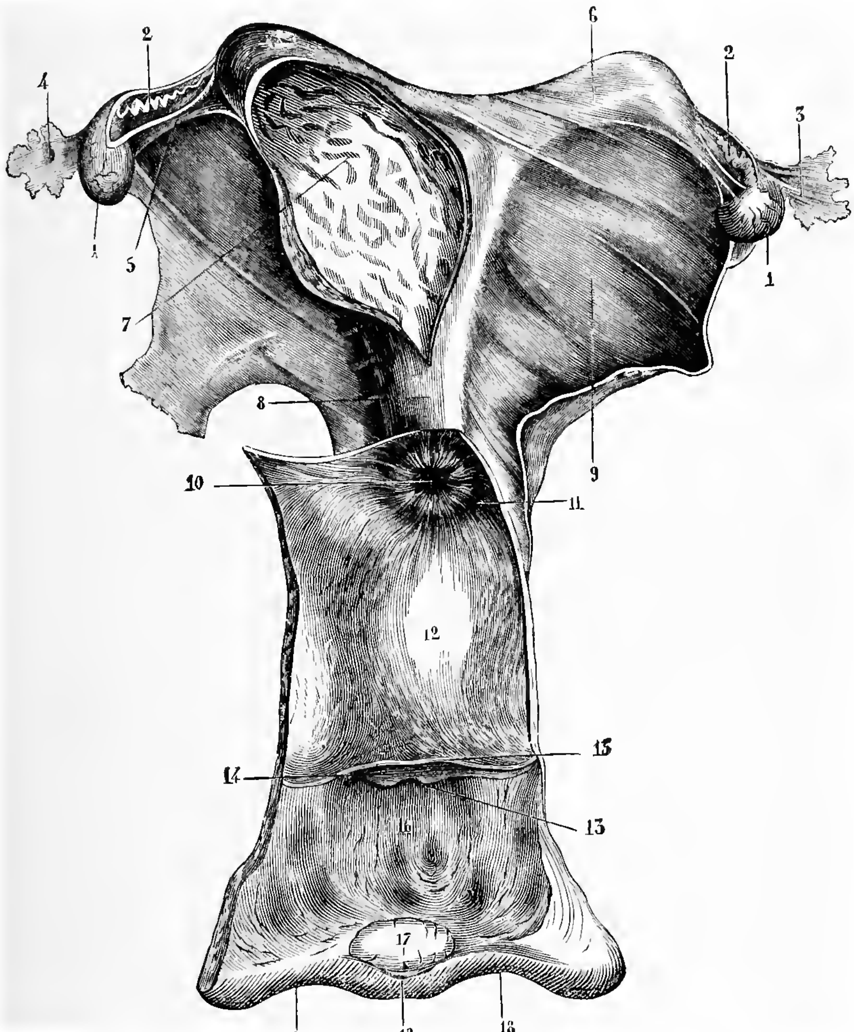
The *body* is related, by its upper face, to the rectum, which lies on it after passing between the two cornua; it receives, on the sides of this face, the attachment of the broad ligaments; its lateral and inferior faces are related to the intestinal convolutions. (*Inferiorly*, it is in relation with the bladder.) Its *anterior extremity* (or *fundus*) is continuous, without interruption, with each of the cornua; the *posterior extremity* is separated from the vagina by a constriction, named the *neck* (*cervix*) *of the uterus*.

The *cornua*, lying among the different portions of intestine which occupy the same region, offer: a free and convex *inferior curvature*; a *superior curvature*, to which the suspensory ligaments are attached; a *posterior extremity*, or *base*, fixed to the body of the organ; and an *anterior extremity* or *summit*—a rounded blind pouch looking upwards, and showing the entrance of the Fallopian tube.

Means of attachment.—Floating in the abdominal cavity, like the intestines, the uterus is also, like them, attached by bands which suspend it to the sublumbar region, and which for this reason have been named the *suspensory* or *broad ligaments of the uterus*.

These bands are two in number, are irregularly triangular in shape, and are more developed before than behind. Close to each other posteriorly, and separating in front like the branches of the letter V, they leave the sublumbar surface and descend towards the uterus, to be attached by their inferior border to the sides of the upper face of the body and the small curvature of the cornua. Their anterior body is free; they sustain the Fallopian tubes and ovaries, the former being placed between the two serous layers of the ligament, and the latter—also within this ligament—receives a band detached from the principal layer, forming with it, beneath the ovary, a kind of small cupola.

Fig. 535.



GENERATIVE ORGANS OF THE MARE, ISOLATED AND PARTLY OPENED.

1, 1, Ovaries; 2, 2, Fallopian tubes; 3, pavilion of the tube (external face); 4, ditto (inner face, showing the opening in the middle); 5, ligament of the ovary; 6, intact cornu of the uterus; 7, a cornu thrown open; 8, body of the uterus (upper face); 9, broad ligament; 10, cervix, with its mucous folds; 11, *cul-de-sac* of the vagina; 12, interior of the vagina, with its folds of mucous membrane; 13, urinary meatus, and its valve, 14; 15, mucous fold, a vestige of the hymen; 16, interior of the vulva; 17, clitoris; 18, 18, labia of the vulva; 19, inferior commissure of the vulva.

There is also another little narrow long band outside the broad ligament, and which can be traced as far as the upper inguinal ring. Anteriorly, it has a small enlarged appendix; between the two layers forming this fold is found a thin muscle, altogether like the male cremaster before the descent of the testicle into the scrotum. This may be looked upon as the analogue of the *round ligament* of Woman.

The uterus is also fixed in its situation by its continuity with the vagina.

Interior.—The inner surface of this organ shows mucous folds, which exist even in the fœtus; they are arranged in a longitudinal series, and are not effacable by distension; though they disappear during gestation, consequent on the enlargement that takes place in the uterine cavity.

This cavity has three compartments: the *cavity of the body*, and those of the *cornua*. The latter are pierced, at their extremity, by the uterine orifice of the Fallopian tube; while the former communicates with the vagina by a narrow canal that passes through the posterior constriction of the uterus (cervix), and which is, in Human anatomy, named *the cavity of the cervix* (*os uteri, os externum, os tricæ*). In all the domesticated animals, except the Rabbit, this canal is prolonged to the bottom of the vagina, in something the same fashion as a tap is into the interior of a barrel; and in this way it always forms a very marked projection in the vaginal cavity. Around this projection, the utero-vaginal mucous membrane is raised in transverse folds disposed in a circular manner, which give it the appearance of a radiated flower; in Veterinary anatomy, this projection of the cervix is consequently named the "expanded flower"—*fleur épanouie*; it is the *tench's nose* of the Human being.

Structure.—The walls of the uterus are composed of three membranes—an external, *serous*; a middle, *muscular*; and an internal, *mucous*; with vessels and nerves.

The *serous tunic* envelops all the organ; it is an expansion of the broad ligaments, which are prolonged backwards on the posterior extremity of the vagina, and are afterwards doubled in a circular fashion around that canal, to pass over either the rectum, the bladder, or the lateral walls of the pelvis. Between the two cornua this membrane forms a particular frænum, which is only slightly developed in Solipeds.

The *muscular layer* comprises longitudinal (superficial), and circular (deep) fibres, analogous to those of the small intestine. Near the insertion of the broad ligaments, they give off a series of fasciculi which are prolonged between the two layers of these ligaments. These are not the only smooth muscular fibres met with in the ligaments, however; for Rouget has found others throughout their whole extent, but particularly in the vicinity of the ovaries.[1] (Around the cervix uteri, the circular fibres are most dense and numerous.)

In the pregnant animal, the number of fibres composing this layer is much more considerable than in ordinary circumstances; this increase has for its object to permit the dilatation of the uterus, without allowing its parietes to become too attenuated; they do become more or less thin, notwithstanding, according to the species. It has also been remarked that, during pregnancy, the muscular fibres present a manifest striation. (The elements of these fibres are short fusiform cells with long oval nuclei, mixed with a large quantity of embryonic, nucleated connective tissue.)

The *mucous membrane* is very rich in cellular elements, and is thin, delicate, and raised into folds. It is covered by ciliated epithelium, which becomes

[1] Unstriped contractile fibres are also found, in the male, along the spermatic cord, beneath the visceral layer of the tunica vaginalis.

cylindrical in the *os uteri*, and pavemental around the cervix; here also are found calyciform cells—a kind of unicellular glands which secrete the thick mucus found in this part. (The cilia vibrate towards the fundus of the organ. The membrane is closely connected with the muscular tunic, and is composed of embryonic, nucleated, connective tissue, without elastic fibres.) The uterine mucous membrane is destitute of papillæ except at the cervix (where there are many highly vascular papillæ); but it lodges numerous simple or ramified glands, which are straight or slightly flexuous at their extremities. At the cervix, these glands enlarge at the bottom, and assume something of the appearance of acinous glands.

(These mucous glands are designated *simple* and *cylindrical*. The first are most numerous towards the cervix; some, here and there, with their orifices closed, are enlarged, and form small vesicular tumours—the *ovula*, *cysts*, or *glands of Nabothi*; they secrete the peculiar transparent mucus found here. The *cylindrical*, *uterine*, or *utricular* glands are closely clustered together, sometimes bifurcated, often twisted in a spiral fashion, and terminating in a *cul-de-sac* in the substance of the membrane. In structure they resemble other mucous glands, consisting of a *membrana propria*, an epithelium of spheroidal cells at the bottom of the tube, and of columnar cells in its duct. During gestation they are much enlarged, and receive the cotyledonal processes of the placenta. At the period of œstrum, the glandular secretion of the uterus is more active than at other times.)

Vessels—Nerves.—The blood is brought to the uterus by the *uterine* and *utero-ovarian arteries*, and is conveyed from it by veins corresponding to the latter. In animals which have been pregnant several times, the vessels are remarkable for their enormous volume, their tortuousness, and the adhesion of the veins to the neighbouring tissues. (The arteries freely anastomose; they ramify through the muscular and mucous tunics, constituting coarse and fine networks, which ultimately end in the veins. These are very large, and have no valves; the plexuses they form are considerable.)

The *lymphatics* that proceed from the uterus are as remarkable for their number as their size; they pass to the sublumbar region.

The *nerves* supplying the organ come from the small mesenteric and pelvic plexuses. (In the uterus there are several important nerve-ganglia; and during gestation it has been ascertained that the nerves, like the vessels, enlarge, and after parturition return to their former size.)

Development.—Narrow in the fœtus, and in the adult which has not been impregnated, the uterus increases in size in animals which have had young several times.

Functions.—The uterus is the sac in which the embryo is developed. The ovum grafts itself upon the mucous membrane of the organ by its placental apparatus, in order to draw indirectly, from the maternal blood, the materials for its development. This function of the uterus gives rise to most interesting anatomical and physiological considerations, which will be referred to when giving the history of the ovum.

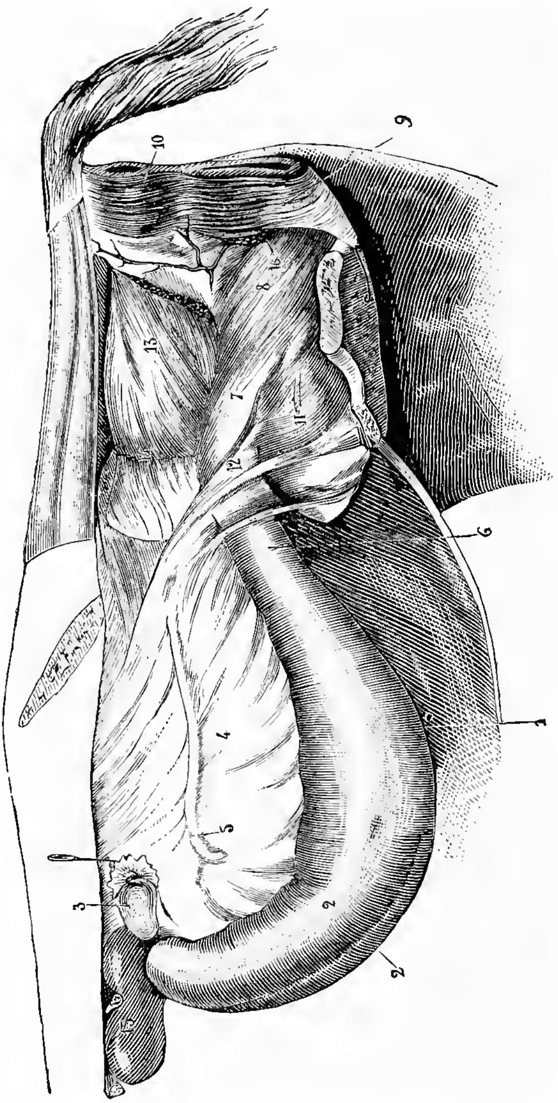
4. The Vagina (Figs. 535, 536).

The *vagina* is a membranous canal with thin walls; it succeeds the uterus, and terminates posteriorly by an external opening—the *vulva*.

Situation and Relations.—Situated in the pelvic cavity, which it passes across horizontally, the vagina is in relation with the rectum above, below with the bladder, and laterally with the sides of the pelvis and the ureters. Connective and adipose tissues surround it posteriorly.

Internal conformation.—The inner surface of the vagina is always lubricated by an abundance of mucus, and is ridged by longitudinal folds (*columnæ rugosæ*).

Fig. 536.



GENERATIVE ORGANS OF THE MARE *in situ*.

1, Body of the uterus; 2, 2, cornua; 3, ovary, with the pavilion of the Fallopian tube hooked back; 4, broad ligament; 5, rudimentary round ligament; 6, cervix uteri; 7, vagina; 8, anterior constrictor of the vulva; 9, posterior ditto; 10, sphincter of the anus; 11, bladder; 12, ureter; 13, rectum; 14, circular fold of peritoneum surrounding the rectum; 15, kidney; 16, bulb of the vagina.

In front, at the bottom of the canal, is observed the projection formed by the cervix uteri; posteriorly, this surface is continuous with that of the vulva.

STRUCTURE.—The vagina is formed of two tunics—an inner, *mucous*, and an external, *muscular*. The *mucous membrane* (pale red in colour) is continuous with that lining the vulva and the uterus (and bladder); it is provided with papillæ, and is lined by stratified squamous epithelium. It contains some closed follicles. (It consists of connective and elastic tissues, to which its extensibility and firmness are due.)

The *muscular coat* is rose-coloured, and traversed by a large number of vessels; it is surrounded, for the greater part of its extent, by an abundance of connective tissue, which unites it to the organs contained in the pelvic cavity; in front, however, it is enveloped by the peritoneum, which surrounds the vagina before passing to the uterus. (This connective tissue is sometimes designated the *third* or *fibrous* tunic of the vagina. The muscular fibres are unstriped, and arranged in circular and longitudinal series; towards the posterior portion of the canal they are redder than in front.)

Vessels and nerves.—The vagina is supplied with blood by the *internal pudic artery*; this fluid is carried from it by numerous veins, which are disposed in a plexus around the canal, and enter the satellite of the artery. The *nerves* come from the pelvic plexus. (The *lymphatics* accompany the veins, and pass to the pelvic glands.)

FUNCTION.—The vagina receives the male organ during copulation, and through it the fœtus passes during parturition.

5. THE VULVA (Fig. 535).

The external orifice of the vagina, the *vulva* is situated in the perinæal region, immediately below the anus. We will consider in succession its *external opening*, its *cavity*, and its *structure*.

EXTERNAL OPENING.—This is a vertical elongated slit, presenting *two lips* and *two commissures*. The *lips* (*labia vulvæ*) are covered externally by a fine, smooth, unctuous, and (almost) hairless skin, rich in colouring pigment, and lined internally by mucous membrane; on their free margin, the limits of these two membranes are well marked. The *superior commissure* is very acute, and almost meets the anus, from which it is nevertheless separated by a narrow space —the *perinœum*. The *inferior commissure* is obtuse and rounded; it lodges the clitoris.

CAVITY OF THE VULVA.—By all Veterinary authorities, this cavity is described as belonging to the vagina, to which it forms the entrance; but considering the analogies that exist between the genital parts of Woman and those of animals, this cavity must be distinguished from that of the vagina. It offers for study the *hymen*, which separates the two cavities, the *meatus urinarius* and its *valve*, and the *clitoris*.

The Clitoris—Exactly like the corpus cavernosum of the male—which it represents in miniature—and from 2 to 3 inches in length, the clitoris commences by two crura fixed to the ischiatic arch, and covered by a rudimentary erector penis muscle. After being attached to the symphysis by means of a suspensory ligament analogous to that of the male, it passes backwards and protrudes into the vulvular cavity, towards the inferior commissure. Its free extremity, lodged in that cavity, is enveloped by a mucous cap—the *prepuce of the clitoris* (*præputium clitoridis*), which is folded in various directions, and excavated about the centre of the tubercle by a small *follicular cavity* that represents the extremity of the male penis. The organization of the clitoris resembles in every particular that of the corpus cavernosum of the penis—a fibrous framework, erectile tissue, and cavernous vessels. It is the contact of the penis with this organ during copulation, that chiefly occasions the venereal excitation.

The Meatus Urinarius and its Valve.—The urethral canal in the female is very short. It passes immediately beneath the anterior sphincter muscle of the vulva, and after a brief course in the texture of the floor of the vagina, it opens into the vulvar cavity by an orifice covered by a large mucous valve: this is the *meatus urinarius* and its *valve*. The *urinary opening*, placed at the bottom of the cavity, at from $3\frac{1}{2}$ to 5 inches from the external opening, is wider than the male urethra, and will admit sounds of somewhat large size, for the catheterism of the bladder. The *valve* has its free border inclining backwards, to direct the flow of urine towards the exterior, and prevent its reflux into the vagina.

(The female urethra is composed of two tunics: a *mucous*, continuous with that of the bladder and vagina; and a *muscular* coat, also a continuation of that belonging to these organs, and chiefly made up of circular fibres; some flat fasciculi attach it to the periosteum of the ischial bones. The urethra is not surrounded by a *corpus spongiosum*, as in the male.)

The Hymen.—This membrane, when it exists, distinctly separates the vulvar from the vaginal cavity. It is rarely present, however; though we have observed it several times in the adult Mare.[1] It forms a circular partition, fixed by its margin to the vulvo-vaginal walls, as well as to the valve of the meatus urinarius, and is perforated by one or more openings which establish a communication between the vulva and vagina. On many occasions we have found, in old brood-mares, pediculated appendages—the remains of this septum. It is usually represented by a transverse fold of mucous membrane, notched on its free border, which lies above the meatus urinarius.

Structure of the Vulva.—The vulva offers for study in its structure: 1. The *mucous membrane* lining its interior. 2. An erectile body lying on that membrane, and named the *vaginal bulb*. 3. *Two constrictor muscles—anterior* and *posterior*. 4. *Two muscular ligaments*. 5. The *external skin*.

1. *Mucous membrane.*—Continuous with that of the vagina and bladder, this membrane has a rosy colour, which may become a bright red at the period of œstrum. It often shows, near the free border of the labia—and especially on the mucous cap of the clitoris—black pigment patches, which give it a speckled appearance. It has in its substance a great quantity of mucous follicles and sebaceous glands. The latter exist near the free border, particularly about the clitoris, and especially in the space between that erectile body and the inferior commissure of the vulva, where they meet in several small sinuses. (These glands secrete an unctuous matter possessing a special odour; they are most active during œstrum.)

Where the mucous membrane is furnished with papillæ, it is covered by a stratified pavement epithelium.

2. *Vaginal* (or *vestibular*) *bulb.*—This is an organ entirely formed of erectile tissue with wide areolæ; it is divided into two branches (*bulbi vestibuli*), which arise from the vicinity of the crura of the clitoris and pass on the sides of the vulva, where they terminate in a round lobe. Covered by the posterior constrictor of the vulva, the vestibular bulb communicates, inferiorly, with the veins of the corpus cavernosum. The influx of blood into the cells of its tissue contracts the vulvar cavity, and concurs to render the coaptation of the copulatory organs more perfect during coition.

[1] Goubaux gives several instances, in an article on "Parturition in the Domestic Animals," published in the *Recueil de Méd. Vétérinaire* for 1873.

3. *Muscles of the vulva.*—Imperfectly described and determined in books on Veterinary Anatomy, these belong to the category of voluntary muscles. We recognize two, which will be described as the *posterior* and *anterior constrictors*.

Posterior Constrictor of the Vulva.—Analogous to the *constrictor vaginæ* of Woman, this muscle—included in the labia of the vulva—forms a veritable sphincter. Above, its fibres are mixed with those of the sphincter ani, and are attached to the sacrum through the medium of the suspensory ligaments. Inferiorly, the most anterior are fixed to the base of the clitoris; the middle are prolonged between the thighs, and are inserted into the inner surface of the skin.

Inwardly, it is in relation with the vestibular bulb and the mucous membrane of the vulva. Its external face is separated from the skin of the labia by a very vascular cellulo-fibrous tissue capable of tonic contraction, and in the midst of which are always found isolated red fasciculi—dependencies of the principal muscle.

This muscle, in contracting during copulation, constricts the aperture of the vagina and compresses the penis; and as, in consequence of its attachment to the clitoris, it cannot act without raising that erectile body, it applies this to the male organ and causes a greater degree of excitement. With animals in œstrum, the movements of the clitoris are frequently observed to propel that organ outwards, especially after micturition; in this case, the fibres of the constrictor attached to the clitoris erect it by its base, while those which are fixed into the skin between the thighs depress the inferior commissure of the vulva. This double action necessarily exposes the erectile tubercle lodged in that commissure.

Anterior Constrictor of the Vulva.—This muscle is formed of arciform fibres which envelop—below and laterally—the vaginal walls at the entrance of the canal; its extremities are continued, by means of aponeurotic fascia, to the sides of the rectum, where they are lost; some even pass to the inferior surface of the sacrum. By its posterior border, this muscle is mixed with the preceding.

4. *Muscular ligaments of the vulva.*—Traces of the suspensory ligaments of the male penis, these are disposed in the same manner at their origin. After becoming united beneath the rectum, they descend in several fasciculi into the labia of the vulva, and disappear among the fibres of the posterior constrictor.

5. *External skin.*—This is fine and black (or light-coloured), destitute of hair, smooth and unctuous, and adheres closely to the subjacent tissues.

6. The Mammæ.

The *mammæ* are glandular organs; they secrete the fluid that should nourish the young animal during the early months of its life. They are rudimentary in youth, and become developed with the advent of puberty, assuming their greatest development towards the end of gestation; they are most active after parturition, and cease their function, as well as diminish in volume, when the period of lactation has terminated.

Situation.—These glands are two in number, placed beside each other in the inguinal region, where they occupy the situation of the scrotum in the male.

Form.—They are two hemispherical masses, separated from each other by a shallow furrow, and showing in their centre a prolongation called the *teat*, *nipple*, or *mammilla*, which is pierced at its free extremity by several orifices for the escape of the milk; it is by this prolongation that the young animal effects suction.

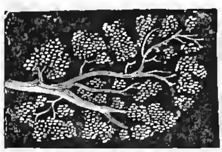
The two glands are fixed in their position by the skin which covers them, and which is thin, black, covered with a fine down, and altogether destitute of hair in the vicinity of, or on, the teat, where the cutaneous surface is smooth, greasy, and supple. They are also attached to the tunica abdominalis by several wide, but short, elastic bands, which resemble the ligaments of the prepuce in the male.

STRUCTURE.—Structurally, the mammary glands offer for study: 1. A *yellow (elastic) fibrous envelope.* 2. *Glandular tissue.* 3. The *galactophorous* (or *lactiferous*) *reservoirs* or *sinuses.* 4. The *excretory canals*, or *mammary* (or *milk*) *ducts.*

The *elastic envelope*, placed in the middle line, beside its fellow of the opposite side, is mixed with the suspensory bands that descend from the abdominal tunic, and sends into the substance of the gland a number of septa, which are interposed between the principal lobules.

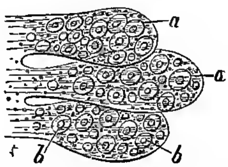
The *glandular tissue* is a compound of *gland-vesicles* or *acini*, clustered in groups around the lactiferous ducts. (The gland-vesicles are made up of an amorphous membrane—*membrana propria*—lined with spheroidal nucleated cells.

Fig. 537.



GLAND-VESICLES, WITH THEIR EXCRETORY DUCTS TERMINATING IN A DUCTUS LACTIFEROUS: FROM A MERCURIAL INJECTION (MAGNIFIED FOUR TIMES).

Fig. 538.



ULTIMATE FOLLICLES, OR GLAND-VESICLES, WITH THEIR EPITHELIUM OR SECRETING CELLS, *a*, *a*, AND NUCLEI, *b*, *b*.

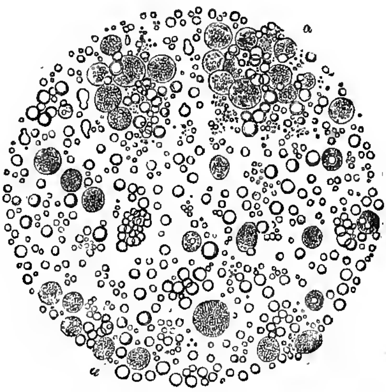
They are $\frac{1}{200}$ of an inch in diameter.) The lactiferous ducts commence by blind extremities, and run into each other to constitute a certain number of principal canals; these open into the galactophorous sinuses (each a *sacculus vel sinus lactiferus*). The glandular *culs-de-sac* are lined with a polyhedral epithelium when the gland is inactive; but during lactation the alveoli enlarge, their walls become thickened by a regular epithelial layer, and their cavities filled with spherical cells which are infiltrated by a great quantity of fat.

Placed at the base of the teat, the *galactophorous sinuses* or *reservoirs* are generally two in number, but sometimes there are three, and even four. They nearly always communicate with each other, and are continued into the mammilla by an equal number of independent excretory canals—the *definitive ducts*, the orifices of which are very small, and are seen beside each other at the free extremity of the teat. A fine mucous membrane lines the inner face of this excretory apparatus; it is doubled in the teat by a thick layer of tissue, which, again, is covered by the skin that adheres closely to it. (Between the external and internal tunic of the teats are found numerous fasciculi of unstriped muscular fibres, arranged in a circular and longitudinal manner around these ducts.)

Connective and *adipose tissue*, *vessels*, and *nerves* complete this organization. The *arteries* are from the external pudic trunk; the *veins* are very numerous, and pass to the abdominal subcutaneous vein; capillaries form a rich network around the alveoli. The lymphatics are very developed. (The *nerves* are derived from the first lumbar pair.)

Functions.—The mammæ secrete the milk; they undergo remarkable modifications at puberty and at the end of each gestation—modifications which are related not only to their volume and secretion, but also to their minute structure. After gestation, the gland-vesicles shrink—become, as it were, atrophied, and have only a polygonal epithelium. At the termination of gestation, they are enlarged, new vesicles are developed, and the epithelium changes its character—filling the gland cavities, assuming a spherical shape, and becoming charged with fat-granules. The period of lactation being completed, the mammæ assume their former character. (In Mares which have not been bred from, the mammæ are hard and small, the teats only slightly prominent, and the glandular tissue scanty. In old brood-mares, on the contrary, they are flaccid and pendent, and the teats somewhat lengthened. The milk secreted by the mammary glands is a white fluid, possessing a sweet taste, and composed of an albuminous water containing caseine in solution, milk sugar, salts, and fatty matter in globules—the *butter*. Usually a small quantity is secreted some days before parturition; that which is yielded for a short time after that period—the *colostrum*—is rich in white corpuscles, and has purgative properties. The colostrum is of a rich yellow colour, less fluid than the milk of a later period, of a higher specific gravity, slightly acid, and containing large oil-globules, a few irregular flakes—probably epithelium-scales—a little granular curd-like matter, and a small number of granular corpuscles.)

Fig. 539.



MICROSCOPICAL APPEARANCE OF MILK, WITH AN INTERMIXTURE OF COLOSTRIC CORPUSCLES AT *a*, *a*, AND ELSEWHERE.

Differential Characters in the Female Genital Organs of the other Animals.

Certain organs offer some differences worthy of notice, while others are formed as in Solipeds.

Ruminants.—*Ovaries.*—In the **Cow**, the ovaries are relatively much smaller than in the Mare, but their form and structure are identical. (The Graafian vesicles are visible through the tunica albuginea.)

Uterus.—The uterus of the **Cow**, compared with that of the Mare, offers but few differences with regard to its general disposition in the pelvic and abdominal cavities, except that it is not so advanced in the latter. Supposing the uterus to be perfectly horizontal, a transverse line drawn through the plane of the abdomen, before the external angle of the ilium, is exceeded by the extremity of the cornua from about 1½ to 2 inches; so that if the animal were on its back, the uterus would only be prolonged to the fourth or fifth lumbar vertebra.

With regard to form, the uterus of the Cow presents a very remarkable disposition, which it is necessary to note. The concave curvature of the cornua looks downwards, while in the Mare it looks upwards; though in both the sublumbar ligaments are attached to this concavity. Therefore it is that in the Cow—if we consider the uterus as freely suspended in the abdomen—the extremity of the cornua is twisted outwards and upwards, while the base, although drawn in the same direction by these ligaments, maintains its direction, because it is in a manner fixed by the body of the uterus. The latter receives, like the cornua, the insertion of the broad ligaments on its lower plane, so that it overlaps them, while the uterus of the Mare projects below them. Otherwise, these ligaments are very ample, especially at their anterior border; they are wide apart in front, towards their lumbar attachment, which is prolonged even on the parietes of the flank. The ligaments may be altogether compared to a triangular cravat, one angle of which is attached to the bottom of the pelvic cavity, and the other two to the tuberosities of the ilium. On this cravat lies the body and part of the cornua of the uterus.

The uterine cornua are thin and tapering at their anterior extremity. The body is short and narrow.

The interior of the uterus of the **Cow** is less ample than that of the Mare. Its surface is studded with rounded tubercles, known as *cotyledons*, which will be studied hereafter. It is only necessary to say here that they are numerous in the cornua, but small and few in the body of the organ.

The cervix uteri, about from 2¾ to 3¼ inches long, is narrow and irregular. The "expanded flower," more finely plicated than in the Mare, is almost cartilaginous. Three other plicated rings, each smaller than the other, are échelonned in the cavity of the cervix, from the external orifice to the body (corresponding to the *plicæ palmatæ*, or *arbor vitæ uterina*, of Woman.)

In structure, the muscular layer is generally thicker than in Solipeds.

In the **Sheep** and **Goat,** the arrangement is the same as in the Cow, except that the cotyledons are hollowed like a cup in their centre, and deserve their name. (The cornua are longer and more pendent than in the Cow.)

In the **Camel,** the cervix uteri is very long, and is encircled by six corona of superposed mucous folds, hard and rigid on their surface. The cavity in the body is divided in two for the greater part of its extent, by a septum formed by the junction of the two cornua.

Vagina.—In the **Cow,** the sides of the vagina are traversed, for a certain distance, by a mucous canal that opens into the vulvar cavity, beside the meatus urinarius. These ducts, the use of which is unknown, are designated the *canals of Gærtner.* They are not present in the **Sheep** or **Goat.** (In Ruminants, the vagina is longer, and its external tunic thicker, than in the Mare. Leyh describes the canals of Gærtner as present in the Mare, though rarely.)

Vulva.—This has thick labia in the **Cow.** The inferior commissure is acute, and furnished with a tuft of hair. (The corpus cavernosum of the clitoris is longer, thinner, and more flexuous, and the glans much smaller, than in the Mare.) The meatus urinarius is disposed as in the Mare; but there exists, on the floor of the urethra, a valve the free border of which is directed backwards. This valve surmounts a small *cul-de-sac*, which it is necessary to avoid in catheterism of the bladder. At about an inch from the entrance to the vulva, there are found in the texture of the labia the *vulvo-vaginal glands* (*glands of Bartholine*). Discovered by Duverney, described by Bartholine, and recently by Colin, these glands (two in number) are about the size of a large almond; their wide extremity is directed upwards, and the narrow end, situated in the vicinity of the *ischio-clitoridis* muscle, gives origin to the excretory canaliculi. They are yellow racemose glands, and their ducts unite to form a kind of sinus, which at length opens in the vaginal cavity, about 4 inches from the labia of the vulva. (These *glandulæ vaginæ* are supposed to be analogous to the prostate glands, and are covered by muscular fasciculi. They are composed of pyriform glandular vesicles, lined by squamous epithelium, and surrounded by a dense nucleated connective tissue; the excretory ducts are invested by columnar epithelium, and surrounded by a thin layer of smooth muscle-cells, disposed longitudinally. Their secretion is a clear, yellowish, viscid mucus.)

(In the **Sheep** and **Goat,** the labia of the vulva have several folds externally, and the inferior commissure terminates in a point.)

Mammæ.—In the **Cow,** each lateral mammary mass—although enclosed in a single fibrous capsule—is composed of two distinct glands, each having its *teat;* so that this animal really has *four mammæ* and *four teats.* There are also frequently found behind these, two rudimentary imperforate (sometimes, though very rarely, perforate) teats.

In the centre of each gland, at the base of the teat, is a single *galactophorous sinus*, the general confluent of all the *lactiferous ducts*—a wide cavity opening at the extremity of the teat by a definitive excretory canal.[1] (The mammæ of the Cow occupy the same region as those of the Mare, and the teats are longer and thicker.)

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[1] Sanson has seen, at Grignon, a Cow with seven teats, all giving milk. He has also seen two teats communicating with the same galactophorous sinus, and he believed that there are only two mammæ, no matter how many teats there may be. Goubaux is of opinion that

In the **Sheep** and **Goat**, there are only two mammæ, as in the Mare and Ass, though they are formed as in the Cow. The Goat has frequently two posterior rudimentary mammæ.

Pig.—The ovary of the **Sow** has a lobulated aspect, like the ovary of Birds. This appearance is due to the ovisacs which, when they are well developed, project beyond the surface of the ovarium, instead of remaining encysted in its stroma. The oviduct is less flexuous, but its length is proportionately greater than in the other species. The body of the *uterus* is short, but the cornua are very long and folded, and float amongst the intestinal convolutions. (Its cervix does not project into the vagina, and the two cavities—vagina and uterus—are continued into each other without any marked limit between them. The mucous membrane is very loose, soft, and fine to the touch, and its surface is gathered up into numerous folds of various forms. The broad ligaments resemble the mesentery, and the cornua join the Fallopian tubes without any very perceptible limit.)

The vagina shows Gærtner's canals, as in the Cow. (Its mucous membrane has numerous longitudinal folds anteriorly; and in front a multitude of fine points, which are the excretory ducts of small glands analogous to the prostates. On the sides of the *meatus urinarius* are two small fossettes surrounded by a ring. There is no *vaginal valve.*) The inferior commissure of the *vulva* is more acute than in Ruminants. The mammæ are ten in number, disposed in two rows, extending from the inguinal region to below the chest. They have no galactophorous reservoirs, as in the larger Ruminants—the lactiferous ducts uniting directly into a variable number of definitive canals that pass through the teat, to pierce its extremity by from five to ten orifices. (There are, of course, five or six glands in each row, each with its teat.)

Carnivora.—In the **Dog** and **Cat**, the *ovaries* and *uterus* are disposed as in the Pig; the ovaries (are situated behind the kidneys, and) are lodged in a particular fold of the broad ligaments, which forms a kind of cup. There are no Gærtner's canals in the *vagina.* The *vulva* of the **Dog** is triangular, and acute at its inferior commissure. The **Cat** has a small bone in the clitoris. The *mammæ* are ten in number in the **Dog**, and eight in the **Cat**; they are distinguished, as in the Pig, into *inguinal*, *abdominal*, and *pectoral.* (Each teat has from eight to ten orifices. The *vagina* is long, and wider at the vulva than towards the uterus. Beside the smooth muscular fibres of its external coat, it has white fibres which give it greater thickness and resistance. The mucous membrane forms longitudinal, intersected by transverse, folds; the valve of the meatus urinarius scarcely exists. The cervix of the uterus projects into the vagina, and is even more voluminous than the body, which is short; it is hard to the touch.)

Rodents.—*Ovaries.*—In the **Rabbit**, these organs are about from ¼ to ½ inch in length, and from 1½ to 2 inches in breadth; they are faintly rose-tinted, and the Graafian vesicles and corpora lutea—extremely numerous—are scattered over the entire surface of the glands.

Fallopian tube.—The pavillion of the tube is very developed, and exceeds the ovary in front; it is bent downwards and backwards, in order to be fixed on the ovary.

Uterus.—In the **Rabbit**, the uterus is double, there being really two distinct organs lying beside each other at their origin, but diverging for the remainder of their extent. Their average length is from 4 to 5 inches; each is cylindrical and slightly flexuous, and opens at the bottom of the vagina by a small "expanded flower." The broad ligaments are fixed in the uterus as in the Cow, and the uterus is drawn outwards.

Vagina.—This is flattened above and below, and sustained by the borders of its inferior face; it is from about 2 to 3 inches long, but its origin is not well defined, as the meatus urinarius is more or less crossed by Gærtner's canal, which naturally belongs to the vagina. That canal lies to the left of the meatus, but it soon disappears there, to reappear in the vicinity of the left uterine canal.

Vulva.—Rather more than two inches long, the vulvar cavity is almost entirely situated beyond the ischiatic arch, and is attached, with the rectum, to the inferior surface of the coccygeal region. Its orifice shows *labia majora* and *minora.* The first is garnished, near the inferior commissure, with a tuft of long fine hairs; the second commence towards the superior commissure, and are attached inferiorly to the *clitoris.* The latter organ has for its base a corpus cavernosum 1½ inch long; its free portion is flattened and tapering, and it may become so very salient, when the labia of the vulva are drawn forward, as to resemble a small penis.

The *muscles* of the vulva are: 1. A posterior constrictor. 2. An anterior constrictor—very

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Sanson has met with anomalies. For ourselves, we have found that each teat has a special galactophorous sinus. In this Cow, therefore, there were five mammary glands, one of which was small.

large, commencing at the coccygeal vertebræ, and inserted into the borders of the clitoris. 3. Two *erectores penis* muscles. 4. A subischio-cavernous muscle, less voluminous than in the male, but of the same shape.

Mammæ.—They are disposed as in the Sow and Bitch.

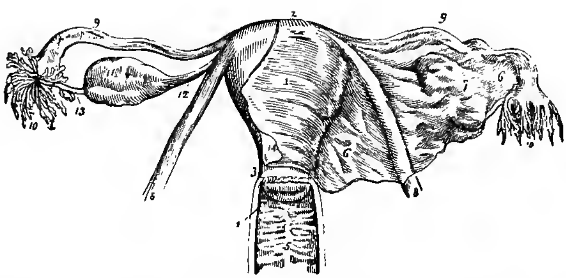
Glands.—The female **Rabbit** possesses, like the male, a pair of rectal and a pair of anal glands.

In the female **Leporide,** it is remarked that the external genital organs resemble those of the Rabbit, and that the internal ones hold a middle place between those of the Rabbit and doe-Hare; otherwise these organs show everything necessary for reproduction.

Comparison of the Generative Organs of Woman with those of Animals.

Ovaries.—These organs are oval, about $1\frac{1}{2}$ inches long and $\frac{4}{5}$ of an inch broad, and are lodged in the posterior layer of the broad ligaments. They are attached to the uterus by the ligament of the ovary, and united to the Fallopian tubes by the Fallopio-ovarian ligament. Their structure is the same as in animals. A Graafian vesicle usually ripens every month; its rupture corresponds with the menstrual period. Annexed to the human ovary is found the *organ of Rosenmüller,* composed of from fifteen to twenty tortuous tubes opening into a transverse

Fig. 540.



UTERUS OF THE HUMAN FEMALE, WITH ITS APPENDAGES (VIEWED FROM THE FRONT).

1, Body of the uterus; 2, fundus; 3, cervix; 4, os uteri; 5, vagina, with its columna and transverse rugæ; 6 6, broad ligament of the uterus; 7, convexity of the broad ligament formed by the ovary; 8, 8, round ligaments of the uterus; 9, 9, Fallopian tubes; 10, 10, their fimbriated extremities; 11, ovary; 12, utero-ovarian ligament; 13, Fallopio-ovarian ligament; 14, peritoneum of anterior surface of uterus (it is removed at the left side, but on the right is continuous with the anterior layer of the broad ligament).

branch; these tubes are lined by ciliated epithelium, and filled with a yellow fluid; they form a closed system included in the broad ligament, between the ovary and oviduct.

Oviduct.—Placed at the upper border of the broad ligament, it is nearly straight, and terminates by a pavilion notched into about fifteen unequal fringes.

Uterus.—The human uterus is situated between the bladder and rectum, being inclined slightly downwards, from before to behind. Its form is very different from the uterus of the animals we have described, being that of a flattened gourd; its volume varies with age and the number of gestations; it weighs about two ounces. It is described as having a body and cervix. The *body* is triangular, and at the extremities of its upper border the Fallopian tubes open into it. The *cervix* is fusiform; the projection it makes at the bottom of the vagina is the *tench's nose*—a transversal slit bordered by two unequal lips. The inner face of the cervix shows the *plicæ palmatæ*—arborizations formed by the mucous membrane.

There is nothing special to be noticed in its structure.

The *broad* ligaments comprise a quantity of muscular fibres between their layers, and which accumulate at certain points to form accessory folds; among these the most important are the *round ligaments.* These leave the anterior face of the uterus, pass forward and outward, enter the inguinal canal, and terminate in the connective tissue of the mons Veneris.

Vagina.—This canal is about $2\frac{3}{4}$ inches wide; it is in contact with the rectum, and responds in front, by connective tissue, to the bladder and urethra. Its internal face has longitudinal folds—the *columnæ of the vagina*—which are intersected by transverse folds. Below the orifice of the urethra is the *entrance to the vagina,* a circular opening partially closed by the *hymen* in virgins. Rarely complete, this membrane may affect different shapes, and consequently receive various names—as *horse-shoe*, *bilabial*, *semilunar*, *annular*, and *fringed hymen*. When ruptured, it retracts very much, but there always remain some vestiges of it, which are designated *carunculæ myrtiformes*.

Vulva.—This presents a cavity and an orifice, as in the domesticated animals; but the cavity is not so deep, and is named the *vestibule;* it extends to the hymen or its *débris*. The *entrance to the vulva* occur in the middle of a cuneiform prominence that is confounded, above, with a kind of eminence—the *mons Veneris*—which appears to protect the pubic symphysis. It is margined by two folds on each side: one cutaneous—the *labia majora;* the other mucous—the *labia minora* (or *nymphæ*). The *labia majora* are convex externally, continuous above with the mons Veneris, and unite below to form an acute angle, named the *fourchette;* they are covered externally with hair. The *labia minora*, more or less developed, leave the fourchette, and extend around the entrance to the vagina, uniting above the clitoris, and forming the prepuce of that organ.

The *clitoris* is lodged in the superior commissure of the vulva; its point is directed downwards, especially during erection; its base is attached, on each side, to the two erectile lobes which constitute the *bulb of the vagina* (*bulbi vestibuli*).

Two racemose glands—the *vulvo-vaginal*, or *glands of Bartholine*—pour their secretion over the walls of the vestibule.

Mammæ.—These are pectoral, and two in number. In their centre, they present an enormous papilla—the *nipple*—into which the excretory canals open; it is surrounded by a brown circle, the *areola of the nipple*.

CHAPTER III.

Generative Apparatus of Birds.

1. Male Generative Organs.

The generative organs of the male are the testicles, and an excretory apparatus much simpler than that of Mammals.

Testicles.—These organs are placed in the sublumbar region of the abdominal cavity, behind the lungs, and below the anterior extremity of the kidneys, in front of the three last ribs. Their form is usually oval, and their volume varies with the different species, as well as at different seasons; at the breeding-season they are greatly developed.

Excretory apparatus.—In Birds there is not, properly speaking, an epididymis. The vas deferens passes from within the posterior extremity of the testicle, is directed in a flexuous manner backwards, draws near to the ureter on its own side, going along the kidney with it, and arriving at the cloaca, where it terminates by an orifice to be alluded to hereafter. In the Duck, it has near its termination a small oval vesicle, always filled with spermatic fluid.

Organ of copulation.—This varies with the species. In the **Gallinacæ**, it is only a small papilla, placed below, near the margin of the cloacal opening, and between the two orifices of the deferent canals. This papilla is traversed by a furrow, through which the semen flows.

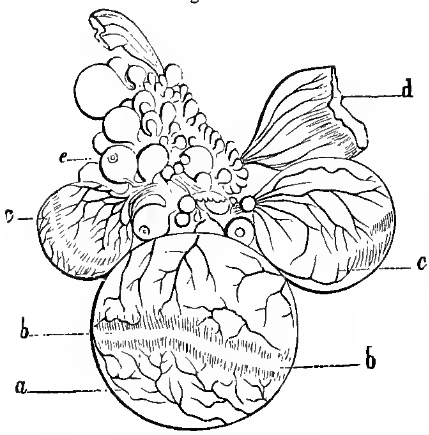
In the **Palmipedes**, this organ is much more developed, and is peculiar. Contained within a tubular cavity in the cloaca, it is protruded externally at the moment of copulation by the eversion of this cavity, like the finger of a glove; it then appears as a long pendent appendage, twisted like a corkscrew.

2. Generative Organs of the Female.

The development of the young animal taking place external to the female, the generative organs are limited to that producing the ovum, and the duct through which it passes on leaving the ovary.

Ovary.—In birds there is only one ovary, which is situated on the left side, the right one becoming atrophied very early in nearly all species. This ovary is situated, like the testicles, in the sublumbar region of the abdominal cavity, and constitutes a more or less voluminous body, composed of a variable number of ova in process of development—some very young, little, and white; others more advanced in age, being larger and yellow in colour. The ova are enveloped in a very vascular cellular membrane, which, when they are ripe, splits in a circular manner, following an equatorial line, and permits the escape of the essential part of the egg—the *yellow* (*yolk*), or *vitellus*.

Fig. 541.



OVARY OF THE BIRD.

a, *c*, *c*, Ova (eggs) in the various stages of development; *b*, streak without vessels, indicating the point where the vesicle is about to rupture to allow the ova to escape; *d*, ruptured vesicle; *e*, very small ovum showing the cicatriculus.

Oviduct.—This duct is long, very wide and dilatable, and very flexuous. It begins, near the ovary, by an unfringed pavilion, and terminates in the cloaca by a somewhat narrow orifice, which is considerably widened when the egg passes through it.[1] The egg—composed, on entering the oviduct, of the fundamental part named the yolk, or *vitellus*—is enveloped in an albuminous covering during its progress towards the cloaca, and afterwards with a protecting shell. The oviduct of birds is, therefore, something more than an excretory canal, as it participates in the formation of the ovum. It is composed of three membranes—an *external* serous, maintains the tortuous tube; a *middle*, muscular; and an *internal*, mucous.

In the two sexes, above the cloaca there is a diverticulum named the pouch of Fabricius, which is extirpated in Brittany, in order to render the hen birds sterile.

[1] Instances of abdominal "egg-laying" have been observed. Reul gives examples in which it was due to atresia of the oviduct (*Annales de Méd. Vetérinaire de Bruxelles*, 1887).

BOOK IX.

EMBRYOLOGY.

Embryology has for its object the study of the modifications which the ovum undergoes, from the moment it is fecundated until it is transformed into a new being capable of living in the external world.

The points of this subject, belonging to the domain of anatomy, will be divided into three chapters. In the first, the transformations of the ovum which produce the embryo will be examined. In the second, the various portions of the ovum—the annexes of the fœtus—will be studied ; and the third will deal with the development of the fœtus.

CHAPTER I.

The Ovum and its Early Embryonic Developments.

Article I.—The Ovum.

The ovum of the domestic mammifers is a vesicle about $\frac{1}{1800}$ of an inch in diameter (the germinal spot being from $\frac{1}{3600}$ to $\frac{1}{2400}$ of an inch), contained in the Graafian follicle, in the midst of the *cumulus proligera*.

It possesses : 1. An amorphous, transparent enveloping membrane, ·01 mm. thick, named the *vitelline membrane*, or *zona pellucida*. 2. A hazy viscid fluid, holding in suspension a large number of dark-coloured granules and fat-globules : this is the *vitellus*, or *yolk*. 3. The *germinal vesicle*, a spherical transparent nucleus lying to one side of the vesicle, and readily altered. The *germinal spot*, a kind of very brilliant nucleolus seen in the centre of the nucleus.

According to Balbiani, there also exists in the ovum of all animals—from insects up to Mammals—beside the germinative vesicle, a second nucleus—named *Balbiani's* or the *embryogenous vesicle*—which plays a very important part in the nutrition of the ovum and the phenomena succeeding fecundation.

Article II.—First Embryonic Developments.

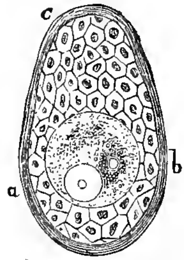
These include three important events—the *segmentation of the vitellus*, the *formation of the blastoderm*, and the *appearance of the embryo*.

These phenomena have been particularly studied in the ovum of the Rabbit, and it is to the researches of Van Beneden on this subject that science owes the most important information on the first phenomena that occur after fecundation in the Mammalia.

1. Segmentation of the Vitellus.—This takes place immediately after

fecundation ; and although we have not to treat of fecundation itself, yet it is well to bring forward the essential fact resulting from modern investigations on this point, showing that this great act consists in the fusion of two germs —the *female pronucleus*, arising from the division of the germinal vesicle ; and the *male pronucleus*, due to the transformation and migration of the spermatozoid. These two elements, by their fusion, originate the *yolk-nucleus* which, by its double origin, contains the material elements of hereditary continuity.

Fig. 542.



A GRAAFIAN VESICLE, FROM A WOMAN THIRTY-TWO YEARS OF AGE.

In this is seen the epithelial covering formed of polygonal cells, and an ovum in which there is at *a* the germinal vesicle with its spot, and at *b* the embryogenous vesicle, much smaller, and surrounded by numerous granules which are disseminated in the vitellus; *c* is the zonula pellucida.

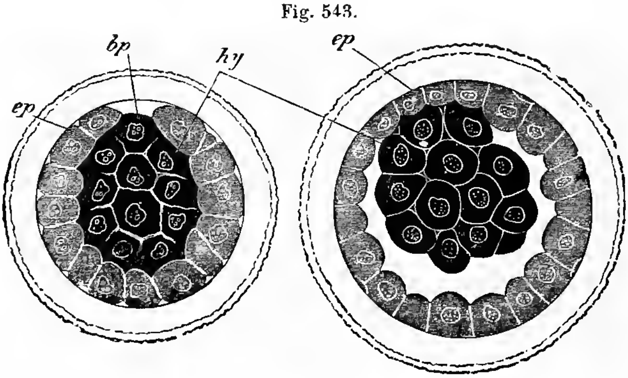
The division of the yolk-nucleus begins and determines the segmentation of the yolk—equivalent to cell-proliferation.

Before becoming segmented, the yolk separates from its enveloping membrane, retracts, and leaves around it a space occupied by a transparent fluid.

The segmentation of the yolk is total, the entire mass undergoing proliferation, and the first effect of this is the production of two cells resulting from the division of the yolk. These two primary cells, or *segmentation globes*, in their turn divide and give rise to two generations which have different destinies to fulfil. This specialization is already naturally contained in the two primary globes of segmentation, and is marked by particular characters. The two globes are, in fact, unequal in size. The largest—the *ectodermic globe*—is transparent ; the second—the *endodermic globe* —is charged with granules which are readily stained by osmic acid.

The proliferation of the ectodermic and endodermic globes continues, and in such a manner that the segmentation globes issuing from the first proceed towards

Fig. 543.



OPTICAL SECTIONS OF THE OVUM OF A RABBIT IN TWO STAGES, SOON AFTER SEGMENTATION.

ep, Epiblast, or ectoderm ; *hy*, hypoblast, or entoderm ; *bp*, blastopore. The ectoderm and endoderm are differently shaded.

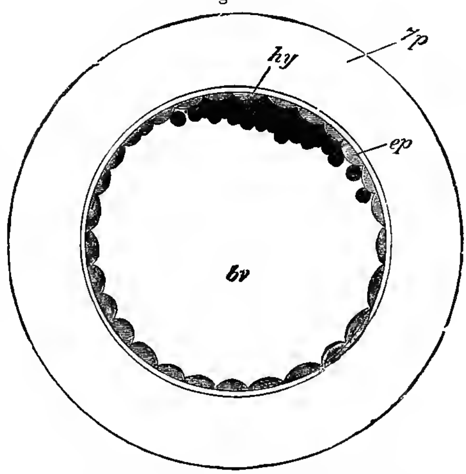
the periphery, and tend to envelop the mass of those which arise from the division of the endodermic globes. Finally, in about seventy hours after fecundation, in the Rabbit, the envelopment is complete.

The yolk is formed of a peripheral layer of clear transparent cells—the *ectoderm*, or *epiblast*—lining the vitelline membrane, and embracing a central mulberry mass (*morula*) of polyhedral and granular cells—the *endoderm*, or *hypoblast*. The ectoderm shows at one of its points an aperture—the *blastopore*, or *anus of Rusconi*—into which penetrates and closes it, but without overlapping it, a prolongation of the endoderm—the *cork of Ecker*. At this phase in its evolution, the yolk constitutes what is termed in comparative embryology, the *metagastrula*.

2. Passage of the Metagastrula to the Uterus, and Formation of the Vesicle and Blastodermic Layers.—As soon as the *metagastrula* has reached the uterus, it commences to be transformed into a clear and transparent vesicle, which grows rapidly, attaining in four or five days a diameter of from 8 to 9 mm., and constituting the *blastodermic vesicle*, or *blastoderm*.

The appearance of the blastoderm is marked by the appearance of a fissure that separates the ectoderm from the endoderm, leaving them only adherent at a point corresponding to the blastopore, which was already formed towards the end of the third day.

Fig. 544.



OVUM OF THE RABBIT, NINETY HOURS AFTER FECUNDATION.

br, Cavity of the blastodermic vesicle; *ep*, epiblast, or ectoderm, forming a complete sac; *hy*, hypoblast, or endoderm, forming the gastrodisc; *zp*, zonula pellucida.

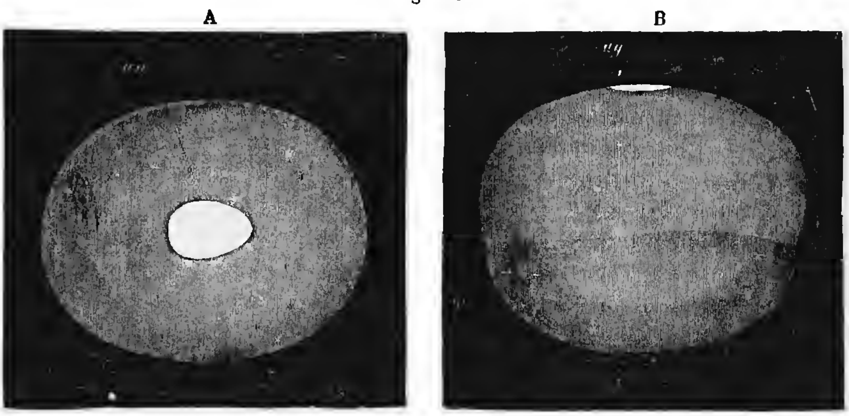
Owing to the pressure of the fluid that fills it and tends to accumulate, the ectoderm becomes distended and fissures; its cells multiply, and it flattens so as to embrace a layer that, towards the ninetieth hour, attains from ·15 to ·17 mm. The endoderm, pressed upon by the fluid, is deformed and spread over a point beneath the ectoderm, where it becomes the *gastrodisc*. The vesicle, formed at this part of two superposed layers, is still monodermic everywhere else (Fig. 544); nevertheless, the cells of the gastrodisc change in character, becoming flattened, and in an ovum of from 105 to 115 hours, having a diameter of from ·9 to 2 mm., they form an endothelial lining to the ectoderm to an extent which increases with the marginal growth of the internal layer.

But all the cells of the endoderm are not so transformed. In ova of five days old, having from 2 to 4 mm. to the centre of the gastrodisc, some are found which have preserved their primary characters of segmentation spheres, and remain interposed between the ectoderm and endoderm—between the external and internal layers. This residual cellular mass, which has escaped the endodermic transformation, is the point of departure of a third layer—the *mesoderm* (*mesoblast*), or *middle layer*, which is already marked at this period by a circular spot at the pole of the gastrodisc. It is this spot that has been known since the time of Bischoff and Coste as the *germinal area* or *streak*. The *germinal*—also named the *embryonal—area* is only at first the optical signification of the appearance of the middle layer, and although the embryo at a later period reveals its first outlines in this part of the blastoderm, it must not be forgotten that it is not yet traced; so that the qualification of embryonal area cannot be accepted in a literal sense.

In the following days, the internal and middle layers continue to grow. By multiplication of the elements of the mesoderm, the germinal area increases in thickness and in surface, pushing up the ectoderm, which becomes salient like a shield, and has a well-defined circular outline. The germinal area at this moment reveals the thickening of the central region of the mesoderm (*mesoblast*), which extends by its borders at the same time as the endoderm, so that the walls of the vesicle are soon composed of three layers throughout.

From the seventh to the eighth day, the blastoderm figures as an elliptical vesicle, somewhat flattened, from 7 to 8 mm. in diameter, filled with a transparent albuminous fluid, and formed of three superposed layers. It does not yet exhibit any traces of morphological differentiation except the germinal area, or

Fig. 545.



VIEWS OF THE BLASTODERMIC VESICLE OF A RABBIT ON THE SEVENTH DAY.
A, FROM ABOVE; B, FROM THE SIDE.
ag, Embryonal area; *ge*, limit of the gastrodisc or endoderm (*hypoblast*).

central thickening of the mesoderm. It is true, however, that the outline of the embryo soon becomes apparent, and the three layers of the blastoderm play a distinct part in its formation, which it is necessary to indicate beforehand.

a. The external layer—*ectoderm*, *epiblast*—is also named the *sensory* or *sensitive* layer, because it gives rise to the epidermis or epidermic formation, and to all the nerve-elements of the sensory terminations—retina, organ of Corti, etc.; it also furnishes the outline of the central nervous system.

b. The internal layer—*endoderm*, *hypoblast*—also merits the name of *mucous layer*, as it originates—not the mucous membranes, as is often said—but the epithelium of the post-diaphragmatic portion of the digestive apparatus and the glands annexed thereto—liver and pancreas.

c. The middle layer—*mesoderm*, *mesoblast*—serves as a centre for all the other tissues—connective, muscular, blood-vessels and lymphatics, serous membranes, sexual glands, etc. The multiplicity of its future specializations does not, therefore, authorize a particular denomination, though it is at times designated as the *serous* or *germinal layer*. The qualification of *vascular layer* should not be given to it, as it belongs to a special formation which will be alluded to hereafter.

3. APPEARANCE AND FORMATION OF THE EMBRYO.—The place in which the embryo is developed is prepared by a differentiation in the germinal area. At first opaque throughout its extent, it becomes clear in its central region, and is thus divided into two concentric and circular zones—the *transparent* and the *opaque zone*. The phenomena which follow are easily studied in the Chick, and it is in it that we will observe them. But it is necessary at first to examine the composition of a Bird's egg; though its complexity is due to the circumstance that the development of the embryo takes place externally, and that the germ must therefore carry with it its nutriment and its protective envelopes.

Essential parts.—The egg of Birds—like that of Reptiles and all the Oviparous Vertebrates—is, then, only a germ provided with an enormous quantity of aliment, and it is this mass that constitutes the yolk. The germ itself—that which is the physiological equivalent of the ovum of Mammals—is represented by a small, circular, white spot—the *cicatricula*—situated on the surface of the yolk, beneath the vitelline membrane; in this, exclusively, resides the evolutionary force, and it is this spot which undergoes segmentation. It corresponds, then, to the whole of the vitellus of the ovum in Mammalia, and merits the name of plastic vitellus, to distinguish it from the nutritive vitellus represented by the yolk. Although there is no marked line of demarcation between the two masses, and although from the plastic vitellus there emanates a kind of protoplasmic atmosphere that penetrates the nutritive vitellus, it might be maintained that the latter does not participate to any extent in the segmentation, which remains exclusively localized in the plastic vitellus. In this sense it may be said that the segmentation is *partial* in the ova of the type named *meroblastic*. The ova of Mammalia and those of the same type are, on the contrary, *holoblastic*—ova in which segmentation involves the whole of the yolk.

In the Fowl, whether or not fecundation has taken place, segmentation occurs during the passage of the egg in the tube, and is nearly completed at the moment of laying. The cicatricula visible in the vitelline membrane therefore represents, in the new-laid egg, not the primary and simple germ, but the germ segmented and ready to form the blastoderm. To see this properly, a fresh egg should be opened in water; the centre of gravity of the yolk being eccentric, the vitellus passes in a certain direction, bringing the cicatriculus to the highest pole of the yolk, in the centre of the visible hemisphere.

Accessory parts.—In passing through the oviduct, the ovum—reduced, as we have seen, to the mass of the vitellus—is surrounded successively by: 1. A layer of albumen. 2. A testaceous membrane. 3. A shell.

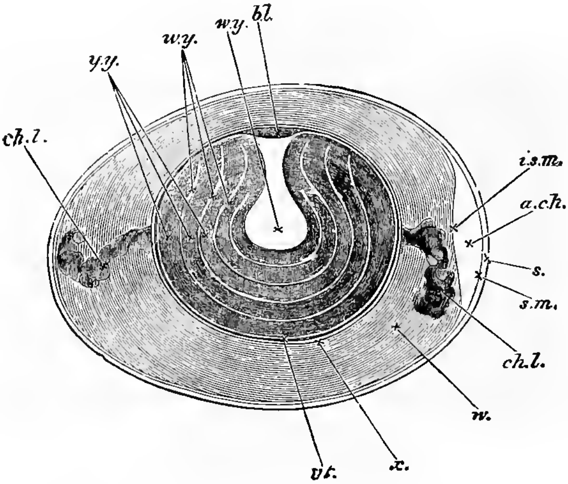
The *albumen*—or "white"—forms three layers of different densities. As, in its progression, the egg is submitted to a rotatory movement on its greater axis, so the albumen undergoes a twist and a particular condensation along this axis; in this way are formed two kinds of coverings, that can be seen floating and adhering to the yolk of eggs opened in water, and which are named the *chalazæ*.

The shell membrane (*membrana putaminis*), fibroid in appearance, at the thick pole is doubled into two layers to form a cavity—the *air-chamber*. This cavity increases as development goes on, in order to meet the respiratory demands of the embryo, or fœtus; while the yolk and albumen become progressively expended as the fœtus grows.

The shell is an organic framework impregnated with lime salts; but it is unnecessary here to enter into a consideration of the very complex details of its structure and mode of formation.

The above description shows the fundamental identity between the holoblastic

Fig. 546.

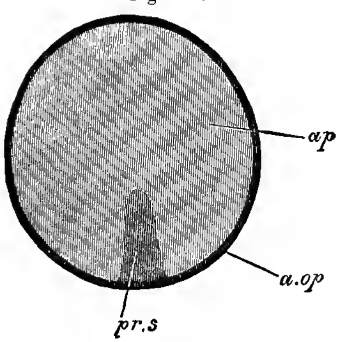


DIAGRAMMATIC SECTION OF A FOWL'S UNHATCHED EGG.

b.l., Blastoderm; *w.y.*, white vitellus, consisting of a pyriform central mass and a certain number of concentric layers; *y.*, yellow vitellus, in alternate layers with the preceding; *v.t.*, vitelline membrane; *x.*, layer of albuminous fluid surrounding the vitellus; *w.*, consistent albumen; *ch.l.*, chalazæ; *a.ch.*, air-chamber; *i.s.m.*, inner layer of the testaceous or shell membrane; *s.m.*, external layer of ditto; *s.*, shell.

and meroblastic ova; they only differ in the enormous predominance of the nutritive vitellus in the latter. This predominance has the mechanical effect of localizing the phenomena of segmentation to one pole of the egg—that in which is the plastic vitellus; and we have seen that this is completed at the moment of laying. The blastoderm that issues from this centre of proliferation necessarily assumes the shape of a disc—the *germinal disc;* then of a spherical cap lying on the yolk by its concavity, and tending to embrace it by the progressive extension of its circular border. This investment is only completed towards the sixth day of incubation, and the blastoderm is therefore late in assuming the vesicular form. Notwithstanding differences of the same kind, arising from another manner of proceeding than that observed in Mammals, the successive formation of the germinal area, and its doubling into an opaque and a transparent zone, take place.

Fig. 547.



AREA PELLUCIDA IN THE VERY EARLY BLASTODERM OF THE CHICK, SHOWING THE PRIMITIVE LINE AT ITS FIRST APPEARANCE.

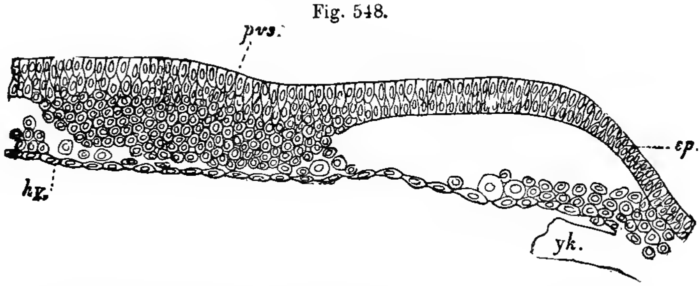
pr.s, primitive trace; *ap*, transparent or pellucid area; *a.op*, opaque area.

The appearance of the embryo is manifested by a temporary formation known as the *primitive trace*—embryonal rudiment, or axile layer. The primitive trace is marked on the blastoderm by two dark streaks close together, separated by a bright line (*primitive streak*), but continuous with each other in front. All the transparent zone in front of the primitive line has been designated by Duval as the *tergal zone*, and we adopt this correct and convenient term. The growth of the primitive line takes place at its posterior extremity, and to this circumstance is due the change in shape of the transparent area, which becomes pyriform.

It is indispensable to see, on transverse sections, the arrangement of the blastoderm and its layers at the primitive trace. The ectoderm, formed of a layer of cubical cells, is curved in the middle, and its deep face becomes confounded with the mesoderm. The latter, formed of small angular cells, is placed between the two layers, and enters the substance of the opaque zone. The endoderm, formed of a single layer of flat cells throughout the extent of the transparent zone, suddenly becomes thicker at the opaque zone, by the stratification of its cells still filled with vitelline granules. These marginal thickenings have been named by Kölliker the *endodermic ridges;* it is to them that the opaque zone owes its optical characters.

This transverse section enables us to see, for the first time, the three super-

Fig. 548.



TRANSVERSE SECTION OF A BLASTODERM OF THE SAME AGE AS FIG. 547.

pvs., Primitive trace; *ep.*, epiblast, or ectoderm; *hy.*, endoderm; *yk.*, above, the endodermic ridge. The section passes nearly through the middle of the primitive trace.

posed layers of the germinal disc; and it exhibits, between the ectoderm and the mesoderm, a curious and characteristic continuity of the primitive trace, which has for a long time exercised the wisdom of embryologists, and given rise to debates now terminated. We will say nothing of the solution arrived at, as it would lead us too far from the scope of this work; and only refer to the primitive trace, because for a long time it passed for what it was not, and also because there was seen in it a trace of the central nervous system, which only appeared morphologically towards the twentieth hour. Destined to retrograde and disappear, the primitive trace is only on the threshold of the embryonal development—an atavic episode, the significance of which cannot be given here, but of which it is necessary to speak, and to point out, in order not to confound it with the origin of the nervous system.

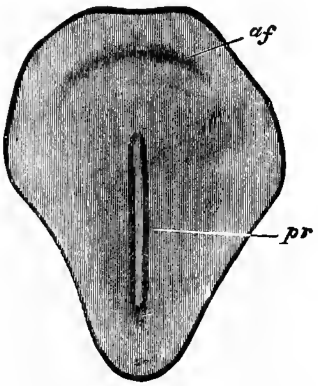
Article III.—General Direction of Development.—Vertebral Type.

The ulterior modifications in the three layers of the blastoderm—inflections, invaginations, doublings—tending to the realization of this type, and from the end of the first day, furnish very interesting indications.

We will study these in a blastoderm from the twentieth to the twenty-fourth hour (Fig. 547).

The outline of the embryo distinctly appears as a very elongated ellipse. At its inferior extremity is seen (Fig. 549) a very slender crescent, the perspective of which does not give so good an idea of its disposition as longitudinal sections do. This appearance of the blastoderm seen on the surface, is due to the inflection of its margins downwards and inwards. The elliptical disc represented by the embryo, and which is lying flat on the yolk, gradually has its borders curved downwards, and converging towards the middle on its ventral face. This inflection of the embryo brings about the formation of the walls of the body and its cavities. In their progressive incurvation, the borders circumscribe an aperture, which contracts and becomes the umbilicus. The inflection proceeds from before to behind, and is constituted by successive folds, which have been

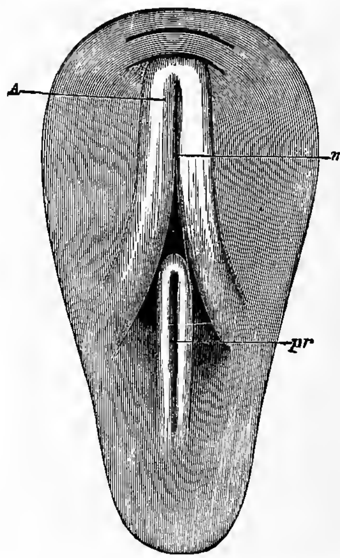
Fig. 549.



AREA PELLUCIDA OF THE BLASTODERM OF A CHICK SOON AFTER THE FORMATION OF THE PRIMITIVE GROOVE.

pr, Primitive trace with the primitive groove; *af*, amniotic fold. The shaded part around the primitive trace shows the extension of the mesoblast.

Fig. 550.



AREA PELLUCIDA IN A BLASTODERM OF EIGHTEEN HOURS, SHOWING THE MEDULLARY GROOVE.

pr, Primitive trace; *m.c*, medullary groove, or dorsal furrow; *A*, medullary fold.

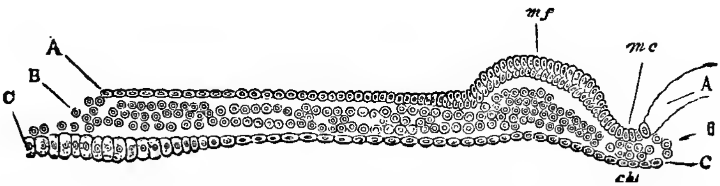
designated, from their situation, as the cephalic fold, lateral fold, and caudal fold.

Fig. 549 shows precisely the commencement of the cephalic fold—that is, the first trace of that grand phenomenon which leads to the formation of the great splanchnic cavities. It may be remarked that, throughout, the three layers of the blastoderm engaged in forming the embryo are continued by their borders with the other parts of the blastoderm. It may also be stated that the embryo is only a morphological specialization of the blastodermic vesicle, and that there is reason to distinguish the embryonal blastodermic layers from the extra-embryonal layers. We shall soon see the why and wherefore, by reason of the continuity of the two regions of the blastoderm, of the modifications in the embryonal layers bringing about correlative modifications in the extra-embryonal layers.

The tergale zone is occupied by a new formation, which appears to be the continuation of the primitive trace, but is in reality altogether distinct. This is a furrow formed by a longitudinal excavation in the ectoderm, and which commences the trace of the central nervous system; it is named the *medullary groove*, or *dorsal furrow*. At the bottom of this groove a dark line betrays the presence of the *chorda dorsalis*, or *notochord*—a provisional skeletal stalk that sustains the medullary groove.

The presence of the medullary groove leads to the division of the embryo into two perfectly distinct zones—the *spinal zone*, corresponding with the medullary groove, and the *marginal zone* comprising all the other part to the borders of the embryo. These facts become very intelligible in a transverse section through the middle of the medullary groove (Fig. 551). It is seen how the latter is formed by the thickening and median inflection of the ectoderm,

Fig. 551.



TRANSVERSE SECTION OF A BLASTODERM AFTER THE FORMATION OF THE MEDULLARY GROOVE AND THE NOTOCHORD.

A, Ectoderm; B, mesoderm; C, endoderm: *mc*, medullary groove; *mf*, medullary fold; *ch*, notochord. The figure represents the left half of the section.

which resembles a V widely open, the two branches of the V constituting the medullary folds (Fig. 550). By their inflection and union they ultimately form a closed tube—the *neural canal*, perhaps better designated as the *neuraxis* (Fig. 552).

The endoderm does not offer any other modification, but the mesoderm undergoes transformations of the highest interest. The interposition of the chorda dorsalis divides it into two symmetrical moieties. The thickened parts, which, in the two moieties, are subjacent to the corresponding medullary fold, form the *lateral layers* (or *plates*). Beyond, the mesoderm shows, in certain embryos at this time, a very marked indication of a decisive event in the evolution of the embryo and the realization of the vertebral type; but it is more convenient to study this in a more advanced embryo.

In transverse sections, the mesoderm can be seen undergoing cleavage into two layers (Fig. 552). The space between these—and which is really a fissure of no importance—grows to a great extent; this is the *pleuro-peritoneal fissure*, which at a later period becomes the *pleuro-peritoneal cavity*.

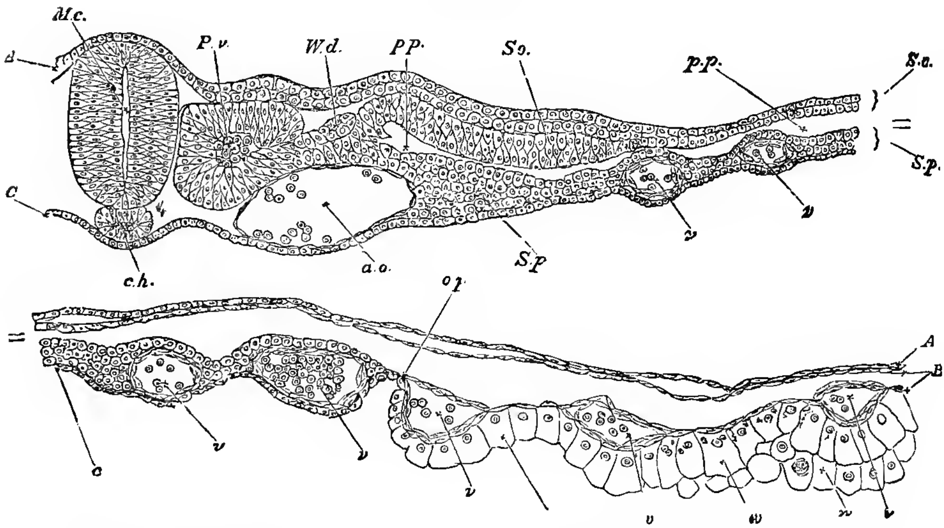
The two layers resulting from the splitting of the mesoderm, perform very different functions. The superficial layer, which furnishes materials for the parieties of the body—including the dermis of the skin—has been named the *musculo-cutaneous layer*; the deeper one is designated the *fibro-intestinal layer*, which sufficiently indicates the direction of its approaching evolution.

In their ulterior modifications, the two layers remain closely allied to the ectoderm and endoderm; and by this association they constitute formations already complex, which it is necessary to note and to qualify. The musculo-cutaneous layer lining the ectoderm constitutes the *somatopleure;* and the fibro-intestinal layer lining the endoderm constitutes the *splanchnopleure.*

But it is essential to remark that phenomena of the same order occur progressively in the extra-embryonal mesoderm, which, throughout its extent, undergoes delamination, and becomes two layers equally allied with the ectoderm and endoderm. It is sufficient to add that the somatopleure and splanchnopleure are continued beyond the embryo by two identical formations, which it is convenient to designate as the *extra-embryonal somatopleure* and *splanchnopleure.*

We have given all the facts and adopted the language which, up to the present, can be embraced in a preliminary view of the general direction of the development and the manner in which the vertebral type is realized, as well as

Fig. 552.



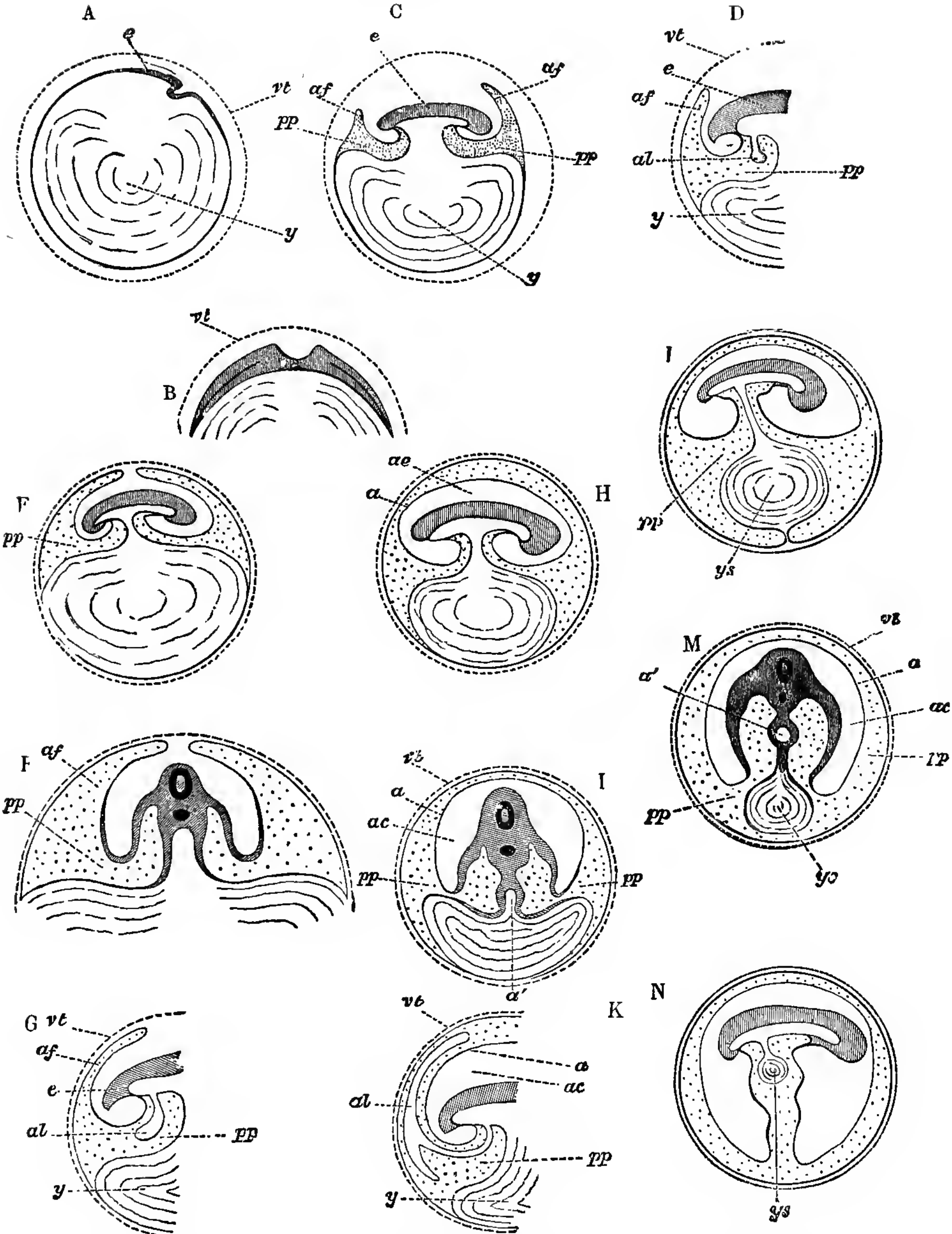
TRANSVERSE SECTION OF THE DORSAL REGION OF AN EMBRYO CHICK OF FORTY-FIVE HOURS.

A, Ectoderm; *B*, mesoderm; *M.c.*, neuraxis; *P.v.*, lateral layer, or mesoblastic limit; *p.p.*, pleuro-peritoneal cavity; *c.h.*, notochord; *S.o.*, somatopleura; *S.p.*, splanchnopleura; *W.d.*, Wolffian canal; *a.o.*, aorta; *v*, blood-vessels; *w*, mesodermic ridge, or germinal wall; *op*, limit of the opaque area and area pellucida. The figure represents the right half of the section.

the correlations between the embryonal and extra-embryonal blastoderms. The study of these correlations allows us to trace the origin of the *envelopes* which protect the fœtus, and are known as the *annexes of the fœtus.*

In Fig. 553 is given a series of sections of an embryo more or less advanced. In sections F and I the embryonal somatopleure and splanchnopleure are already incurvated downwards and inwards. In passing from F to I, we see how the splanchnopleure of each side advance towards each other, and tend to form a tube opened inferiorly at each section—this is the intestine. Its walls, not joined at this point, are continuous with the extra-embryonal splanchnopleure, which is really the *umbilical vesicle;* in Birds, the latter contains the mass of the yolk. Above the intestine are seen the superposed sections of the notochord and neural canal; and it is the order of this superposition that is characteristic

Fig. 553.



FROM A TO N IS A SERIES OF DIAGRAMMATIC FIGURES SHOWING THE MANNER IN WHICH THE EMBRYO AND ITS ENVELOPES ARE FORMED.

vt, Vitelline membrane; *e*, embryo; *pp*, pleuro-peritoneal cavity; *af*, folds of the amnion; *a*, amnion proper; *ae* or *ac*, cavity containing the liquor amnii; *al*, allantois; *a'* digestive tube; *y* or *ys*, vitellus, or vitellin sac.

of the vertebral type. The alliance of the embryonal and extra-embryonal blastoderms has, at the commencement, a form that allows us to understand the origin and mode of formation of the fœtal annexes—*umbilical vesicle*, *amnion*, *chorion*, *allantois*. Before proceeding to the description of these organs, we will examine precisely their origin.

It has been already shown that the umbilical vesicle is nothing more than the whole of the extra-embryonal splanchnopleure. The amnion is derived from the extra-embryonal somatopleure; from F to I this derivation may be followed. Around the embryo the somatopleure undergoes a double inflection—one that establishes the limits between its two embryonal and extra-embryonal parts, and passes up towards the back of the embryo; and another—C—which is continued over the inner face of the vitelline membrane, and is named the *fold*; the amniotic layer comprised between the two inflections constitutes the amnion. This membrane is made complete by the union of the amniotic folds (I); the embryo is entirely enclosed in the amnion. The union of the amniotic folds entails, at the same time as the occlusion of the amnion, the occlusion of the remainder of the extra-embryonal somatopleure, which lines the whole of the internal face of the vitelline membrane, and forms a continuous and independent membrane—the *serous layer*, or, better, the *chorion*.

The umbilical vesicle, the amnion, and the chorion, circumscribe a space named the *external cœlome*, and communicating freely with the pleuro-peritoneal cavity.

In Figs. E and H, showing longitudinal sections, are seen the general relations of all these parts. At *al*, Fig. G, is observed the origin of the allantois, which appears to be only a diverticulum of the last portions of the intestines. The allantoid sac soon passes into the cœlome, and there develops in size and shape according to the species of the animal.

In the preceding chapter, we have seen by what evolutive modes the fœtal envelopes or membranes are derived from the intra-embryonal part of the somatopleure and splanchnopleure. These envelopes or membranes are represented in the diagrammatic figure, 553. To them are joined the cord of vessels and the capillaries that establish the relations between the mother and progeny. The whole receive the name of *annexes of the fœtus*.

CHAPTER II.

THE FŒTAL ENVELOPES OF SOLIPEDS.

Preparation.—The dissection of the annexes of the fœtus is a delicate operation; but a good idea of their arrangement may be obtained in several ways.

1. The embryo should be first removed from the uterus. This is very easily effected in Solipeds, as the adhesions between the placenta and the uterus are nearly always destroyed when dissection is undertaken. With the fœtus of Ruminants, it is necessary to open the uterus from the cervix to the summits of the cornua, the incision passing between the cotyledons. In order to accomplish this, the point of the branch of a pair of scissors is passed between the chorion and uterus, in raising the wall of the latter. The cotyledons are then sought for. With the fœtus of the Cow, the chorion is carefully pulled from the uterine cotyledon in order to separate the placentas; with that of the Sheep and Goat, the cotyledons are pressed between two fingers, in order to expel the chorial villi from their interior.

2. The fœtus being isolated, the chorion is studied with regard to shape and external aspect. To see the relations of its internal face with the other annexes, we may resort to a plan which gives good results with the fœtus of Ruminants. This consists in filling the allantois and amnion by small openings with different-coloured fluids. The limits of the two sacs can then be very well made out through the chorion, while their reciprocal relations can also be observed. With Solipeds, the allantoid cavity must necessarily be opened; the membrane of that name is partially separated from the inner surface of the chorion by blowing in air along the principal divisions of the vessels of the cord, by means of a straw or blow-tube.

3. To complete the study of the amnion and the allantois of Ruminants, it is best to blow in air beneath the chorion, after removing the contents. The chorion is then carefully taken away, in breaking through—by means of the fingers and forceps—the laminal tissue uniting these two membranes; in the same way are destroyed the fasciculi which bind the allantois to the amnion. In Solipeds, nothing is more easy than to inflate the amnion, and to study its shape and relations. The chorial layer of the allantois is demonstrated as already described; a similar procedure is employed to show the existence of the amniotic layer, which is more easily done than with the other.

4. The vessels of the umbilical cord and placenta should be injected, and to make an injection penetrate satisfactorily, the placental vessels, with the fœtus and chorion, should be placed in tepid water for some time.

The *annexes of the fœtus* comprise: 1. A membranous envelope exactly

Fig. 554.

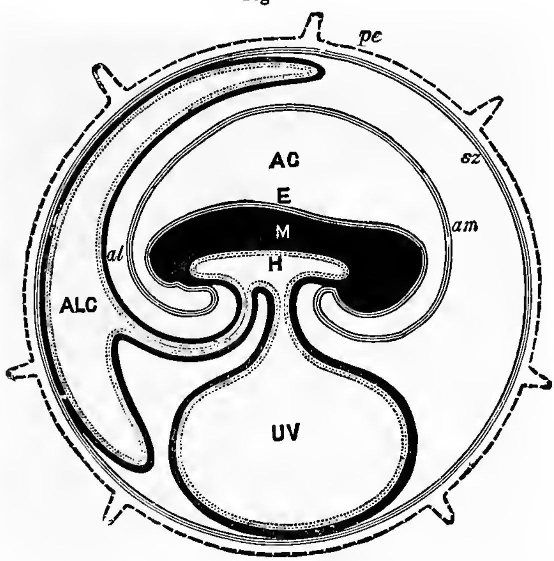


DIAGRAM OF THE FŒTAL MEMBRANES OF A MAMMAL.

pc, Zona pellucida with villi, and *sz*, the remainder of the extra-embryonal somatopleure constituting the chorion; *am*, amnion; AC, cavity of amnion; UV, umbilical vesicle; *al*, allantois; ALC. cavity of the allantois; E, ectoderm, or outer layer of the embryo (epiblast); M, mesoblast (or middle layer); H, endoderm of the embryo (alimentary canal).

moulded on the uterus, and known as the *chorion*. 2. A second ovoid sac included in the first, and containing the fœtus—the *amnion*. 3. The *allantois*—a membrane formed of two layers spread over the inner surface of the chorion and the external face of the amnion, as well as covering the parts between these two envelopes. 4. A small pyriform bladder constituting the *umbilical vesicle*. 5. The *placenta*—a collection of vascular tufts which graft the young creature to the mother. 6. The *umbilical cord*, composed of vessels that attach the fœtus to the envelopes surrounding it, and which ramify in the placental tufts (Fig. 556).

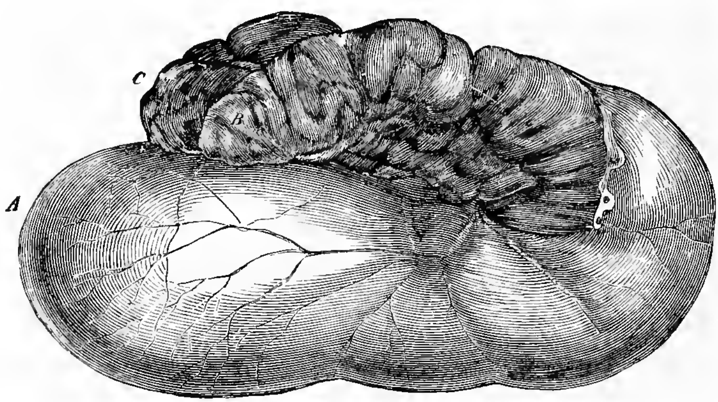
1. The Chorion (Figs. 554, 555).

The outermost envelope of the ovum, the *chorion* is a vast membranous and perfectly closed sac, the shape of which exactly corresponds with that of the uterus. It has a *body* and two *cornua*. The latter, when inflated, are plicated and sacculated like the cæcum, and are always unequal in volume—that in which the fœtus is developed having by far the largest dimensions.[1]

The *external face* is studded with small red tubercles, formed by the placental tufts. It adheres to the internal surface of the uterus. Between the two membranes there is found a small quantity of sanguinolent fluid; but on one occasion, in the Ass, it had the appearance of milk.

The *internal face*, lined by the external layer of the allantois, is united in the closest manner to that membrane, except at the umbilical cord, where there

Fig. 555.



EXTERIOR OF THE CHORIAL SAC (MARE).
A, Body; *B*, *C*, cornua.

exists a kind of conical infundibulum occupied by the umbilical vesicle. Adhesion is established by means of the vessels of the umbilical cord passing into the texture of the chorion, and by very delicate, laminal, interannexial connective tissue.

Structure and Development.—The external covering of the ovum is at first formed by the *vitelline tunic*, itself constituted by the transparent membrane, covered externally by a layer of cells derived from the Fallopian tube or uterus. This *primitive chorion* is replaced by a portion of the extra-fœtal somatopleure, which becomes the *secondary* or *definitive chorion*. It is destitute of vessels until the allantois is developed.

When the chorion is complete, it is composed of three layers: 1. An external epithelial covering, formed of a single layer of uniform cylindrical cells, contain-

[1] When there is only one fœtus, it is always more particularly developed in one cornu, which consequently has an enormous volume when compared with the other. When there are two fœtuses—as often happens in the Ewe—there is one in each cornu; and then the cornua develop in the same manner.

ing at some points fat-granules. 2. A chorial stroma of embryonic connective tissue—fibres, stellate cells, and round and migratory cells in the midst of a large quantity of albuminous fluid. Dastre has observed in this layer opaque plates—*chorial plates*—composed of irregular particles of tribasic phosphate of lime, which ultimately serves for the ossification of the fœtal cartilages. The chorial deposit in Solipeds has the appearance of a network, the meshes and spaces in which are badly defined. 3. A layer of mucous connective tissue that unites it to the allantois.

From this description, it will be seen that the chorion does not play a merely mechanical part in protecting the fœtus and supporting the placental blood-vessels, but that it holds in reserve the materials that will serve for rapid nutritive changes at a given moment.

2. The Amnion (Figs. 556, A ; 557, *C*).

The second sac enveloping the fœtus—the *amnion*—floates freely in the interior of the chorion, to which it is only united at one point through the medium of the umbilical cord. It contains the young creature, which is also attached to its inner face by the vessels of the cord. It has the shape of an ovoid pouch depressed around the umbilical vessels, around which it forms a sheath as it goes to be confounded with the skin of the fœtus. It has thin transparent walls.

Its *external face* is covered by the inner layer of the allantois, to which it adheres slightly. A large number of flexuous vessels, enveloped by a thick layer of mucous tissue, course over this surface. The *internal face* is perfectly smooth, and is applied more or less directly to the skin of the fœtus. It exhales a fluid in which the latter floats—the *liquor amnii.*

Structure.—As the amnion is derived, like the chorion, from the somatopleure, it is not surprising to find in it three superposed layers : 1. A very thin connective-tissue membrane that adheres to the allantois. 2. A proper membrane —also of connective tissue—but containing some muscular fibres, which explains the contration of the amnion observed in the chick. 3. An epithelial lamina lining the latter. There are sometimes met with, at certain points on the inner surface of the amnion, small, white, opaque masses, composed of glycogenic cells, which become brown when treated with iodine.

Liquor amnii.—Enclosed with the fœtus in the cavity of the amnion, this fluid is more or less abundant, according to the period of gestation ; its relative quantity being always less as the fœtus is advanced in development. At an early period it is somewhat milky in appearance, but later it assumes a citrine or slightly reddish tint. It has a salt taste, and contains 99 per cent. of water, with albumen and salts, the principal of which are chloride of sodium and the sulphate and phosphate of lime.

3. The Allantois (Fig. 556).

The *allantois* is a membrane that covers the inner face of the chorion, and is folded around the insertion of the umbilical cord, to spread itself over the whole external surface of the amnion. It thus transforms the chorial sac into a kind of serous cavity, in which the amnios is enclosed as a viscus.

The *inner*, or *amniotic lamina*, is attached to the amnion "so slightly, that dissection, and especially insufflation, easily destroys its adhesion. When the second of these measures is resorted to, in order to separate the two membranes, the allantoid surface assumes a sacculated or blistered appearance, due to the numerous cellular bands that attach it to the amnion. These bands rupture when the inflation is forced, and a noise is heard analogous to that produced by the rumpling of parchment. With a little care, the whole of this portion of the allantois—the extent of which equals that of the amnion—may be entirely detached.

"The degree of adhesion of the *chorial allantois* is more marked. Ordinary dissection—which is easy along the first divisions of the cord—is much more difficult towards the chorion, and soon becomes, if not impossible, at least very arduous, if we desire to separate it. But here, again, inflation demonstrates the existence of the membrane, and its continuity with the portion so easily dissected from the amnion. If, after opening the allantoid sac by cutting through the

Fig. 556.

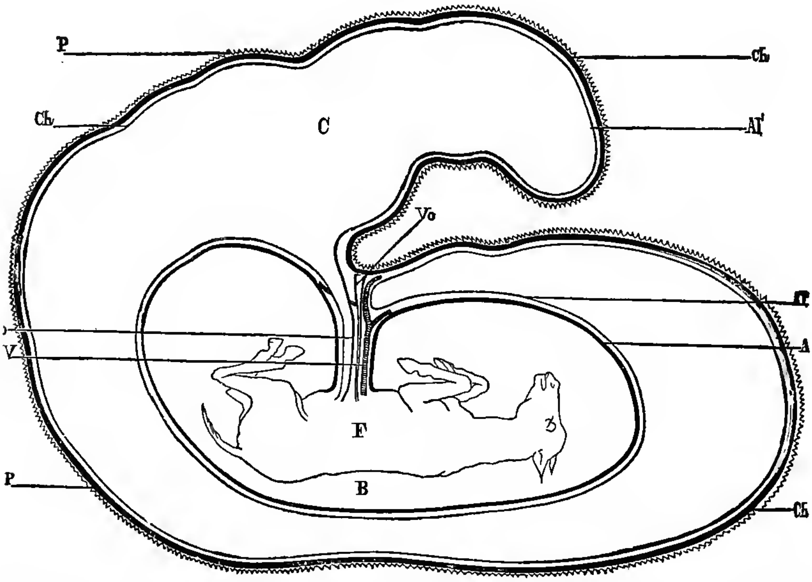


DIAGRAM OF THE DIFFERENT PARTS OF THE FŒTAL HORSE, TOWARDS THE MIDDLE OF GESTATION.

P P, Placenta; Ch Ch, chorion; Al', external lamina of the allantois; Al, internal lamina of ditto; o, urachus; *e*, cavity of the allantoid; A, amnion; B, cavity of the amnion; Vo, remains of the umbilical vesicle; V, vessels of the umbilical cord; F, fœtus.

chorion and the lamina lining it, a tube is introduced between the two membranes —which is readily done near a large vessel—by a slight inflation the air enters between the allantois and chorion, though it only follows the track of vessels of a certain size, to the sides of which there is but little adherence. If the inflation is pushed, the air—following the smallest vascular ramifications—renders the membrane more apparent, though without detaching it from the points where the vessels have almost become capillaries.

"If, instead of injecting the air towards the ramifications, it is propelled in the opposite direction, it will soon be perceived to extend towards the allantoid portion of the umbilical cord, and insinuate itself between the amnion and the allantois covering it—an evident proof of the continuity of the two layers which have been separated for the purpose of studying them, but which are, in reality, only two portions of the same membrane that forms a complete sac."[1]

The cavity of this sac communicates with the bladder by means of a canal divisible into two portions: 1. The *infundibulum*—a wide canal continued in the amniotic portion of the umbilical cord, the walls of which are continuous, on the one part, with the amniotic lamina of the membrane, and on the other part with the chorial lamina, after being prolonged as a sheath around the cord. 2. The *urachus*, a musculo-membranous canal that extends from the umbilicus to the summit of the bladder, with the umbilical arteries on each side (Figs. 556; 557, *D*, *B*).

Structure and Development.—The allantois has the structure of a serous membrane. It possesses: 1. An endothelial lining, the cells of which are thin and polygonal, leaving between them, here and there, stomata that permit the blood-serum to transude through its texture; these cells contain the glycogen. 2. A middle layer or stroma, of the nature of connective tissue, little vascular, and the fibres of which are parallel. 3. An external layer of loose connective tissue, rich in vessels, and resembling subserous tissue; this layer is continuous with the parietal fibrous tissue of the fœtal peritoneum, through the medium of Wharton's jelly.

The allantois, as we have described it, passes beneath the mucous membrane of the bladder instead of being confounded with it.

The blastodermic laminæ—internal and middle—concur in the formation of the allantois; but the middle one has the largest share in this. There is a tendency to believe that the extra-fœtal portion of this vesicle is a cavity formed in the intra-annexial connective tissue, and that this cavity is at a later period transformed into a serous one. In any case, it serves as a support to the vessels passing between the fœtus and placenta.

Allantoid Fluid.—This cavity contains a fluid, the quantity of which increases with age. Colourless and transparent at first, it afterwards becomes amber-tinted, and this gradually deepens; at the same time it grows turbid, and flocculent masses form in it. Its reaction is alkaline, and it has the property of emulsifying fats. It contains albumen, urea, various salts, and sugar—2·5 per 1000 average. The proportion of the latter does not vary much during gestation.

The presence of urea in this fluid, as well as the communication of the urachus with the bladder, has led to the supposition that the urinary secretion of the fœtus contributes to its formation. But this is not demonstrated, and the mere presence of urea is not sufficient to attribute this origin to the allantoid fluid; for the blood, lymph, cerebro-spinal fluid, as well as all other serous fluids, contain a proportion at least as considerable.

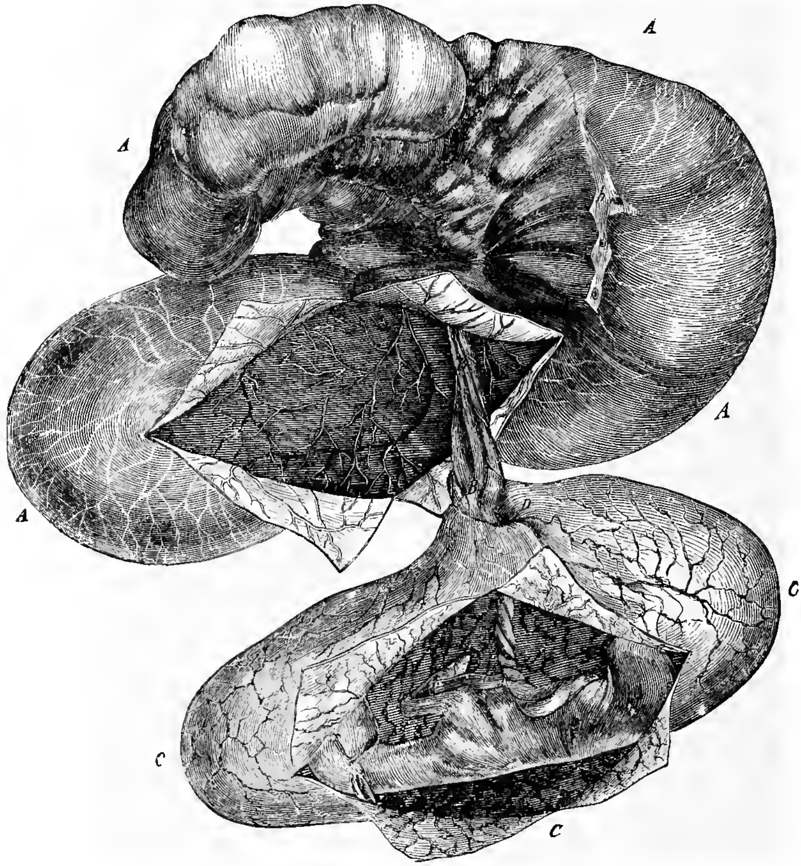
Hippomanes.—This name is given to small brown masses, more or less numerous—though often there is only one—which float in the allantoid fluid. "These bodies, of the consistency of gluten, and elastic like it, are flattened, thinner at the borders than towards the centre, oval or irregularly circular, and about the diameter of a five-franc piece. It is difficult to explain the presence of the hippomanes in the allantoid sac. Nothing in its appearance indicates that it may be formed at the expense of the liquid contained in this membrane. Sometimes pediculated hippomanes are found, and these may assist in explaining the formation of the free hippomanes. Bourgelat speaks, in his *Anatomie*, of pedicu-

[1] F. Lecoq, *Des Annexes du Fœtus.*

lated hippomanes, and I have been able to make the following observations, through having met with a large number on a fœtus :—

"Besides the free hippomanes found floating in the allantoid fluid, there were remarked, on the outer wall of the sac, a great number of small tear-shaped bodies of variable size, adhering by a pedicle which was more or less narrow as the mass was more developed. Their colour was the same as that of the principal hippomanes, and if pressed between the fingers, the brown matter contained in a thin-

Fig. 557.



FŒTUS OF THE MARE, WITH ITS ENVELOPES.

A, Chorion; *C*, amnion removed from the allantoid cavity, and opened to expose the fœtus; *D*, infundibulum of the urachus; *B*, allantoid portion of the umbilical cord; *b*, point of the external surface of the chorion, destitute of placental villi, and corresponding to the part where the three pediculated hippomanes are attached.

walled sac escaped by the pedicle, and spread itself over the external surface of the chorion. There the villosities of the placenta were absent at the margin of the opening, which was surrounded by a whitish areola (Fig. 557, *b*).

"Might it not be admitted, from this disposition, that the hippomanes is developed between the placenta and the uterus, and is carried inward, by pushing before it the chorion and layer of the allantois covering it, until, on reaching the allantoid cavity, it becomes detached, like certain fibrous or cartilaginous bodies in the synovial or serous cavities ?" (F. Lecoq).

According to Dastre, the hippomanes arise between the chorion and the allantois, and they are formed by the phosphatic matter of the chorion, which collects in masses at certain points, where it is enveloped by a mass of the subjacent mucous connective substance of this membrane.

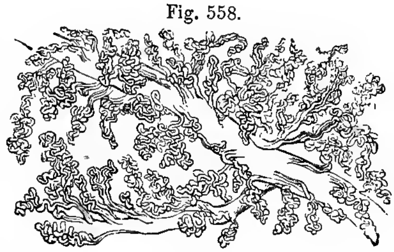
4. The Umbilical Vesicle.

The *umbilical vesicle* is a small fusiform or pyriform pouch, lodged in the infundibulum at the extremity of the umbilical cord. Its fundus adheres to the chorion; the opposite extremity is prolonged to a variable depth in the substance of the cord, and is even continued—in the very young fœtus—to the abdominal cavity, by a narrow canal that communicates with the terminal portion of the small intestine.

This pouch has a red colour, due to its great vascularity. Its walls receive a special artery derived from the anterior mesenteric, its corresponding vein passing to the portal vein. These are the two *omphalo-mesenteric vessels.*

In the last months of fœtal life, the umbilical vesicle is always more or less atrophied; its cavity has disappeared, and it is nothing more than a thin reddish-brown cord. Its vessels also become atrophied in the same manner, and nearly always nothing else is found than the artery, reduced to the dimensions of a thread.

Fig. 558.



PORTION OF THE ULTIMATE RAMIFICATIONS OF THE UMBILICAL VESSELS, FORMING THE FŒTAL VILLI OF THE PLACENTA.

5. The Placenta (Figs. 556, 558, 559).

The *placenta* is the organ which establishes relations between the fœtus and the uterus of the parent. It adheres to the chorion, of which it is only a kind of dependency.

In Solipeds, the *placenta* is composed of a multitude of small tubercles (*placentæ*), spread uniformly over the external surface of the chorion, which they almost completely cover. Their number and development are greatest in the middle portion of the chorion—in the zone where the principal divisions of the umbilical cord lie beside this membrane. Thence they diminish towards the extremity of the uterine cornua and body. In front of the openings of the uterus—Fallopian tubes and os uteri—they are rare. These small tubercles are formed by an aggregation of extremely vascular villi, which implant themselves in the follicles of the uterine mucous membrane. The terminal ramifications of the vessels of the cord constitute the vascular apparatus of these villi (Figs. 558, 559, 560).

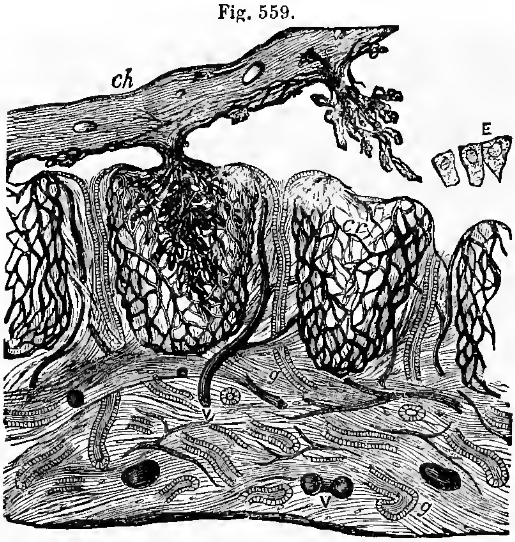
The parts of the uterine mucous membrane which are related to the fœtal placentæ, are named the *uterine* or *maternal placentæ.* They are constituted by follicular cavities, which are formed beside permanent glandular follicles in the mucous membrane during gestation, but they disappear after parturition (Ercolani).

This Italian anatomist compared the cavities of the maternal placentæ to glands which secrete a kind of uterine milk. Laulanié, from a study of the maternal placenta of the Guinea-pig—and which he regards as a colossal multi-nucleated cell, the protoplasm in which is intersected by vessels—is of opinion that the placental cavities in the Mare are of the same character, except that there are several giant cells. There is nothing glandular in the epithelium lining these cavities; on the contrary, they are often confounded with the cells of the deeper part.

These cavities are, then, sinuses lined with blood-vessels, and are not glands. Besides, as may be seen in examining Fig. 559, they are quite distinct from the proper tubular glands of the uterine mucous membrane.

Structure and Development.—The villi of the placenta have for their base a tissue similar to that of the chorion, their stroma being formed by bundles of connective tissue mixed with cells. They are covered by a simple cylindrical epithelium placed immediately on the connective stroma (Fig. 560). Their

Fig. 559.



VERTICAL SECTION OF THE INJECTED PLACENTA OF A MARE.

ch, Chorion, with its villi partly *in situ*, partly torn out of the uterine sinuses, *cr*; *g*, uterine glands; V, blood-vessels; E, epithelium.

interior is occupied by a capillary network, the finest divisions of which are subjacent to the epithelium; the network itself is supplied by a branch from the umbilical arteries, and the blood is returned by a vein nearly in the centre of the villus.

The vessels pre-exist in the villi; consequently, the latter do not develop from the chorial tissue, but rather, it might be said, the chorion is pushed back by the pressure of the vessels. The placenta succeeds, then, the development of the allantois, the use of which is to convey the umbilical vessels from the umbilicus to the chorion.

The villi penetrate the uterine mucous membrane, in such a way that the capillary systems of the mother and fœtus are only separated by the thin walls of the vessels, and the epithelium of the villi and follicles.

The fusion of these two systems has never been observed, and all the interchanges between the female and its young take place through the capillaries by osmotic force only.

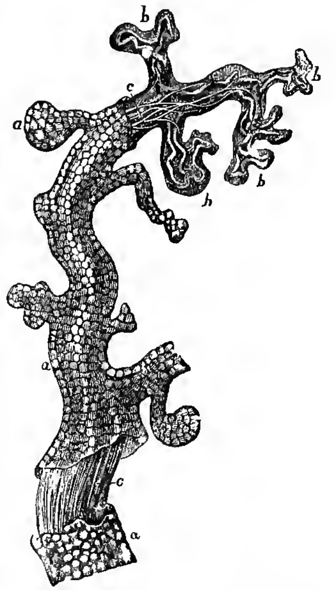
6. The Umbilical Cord (Figs. 556, 557).

The *cord* is formed by the vessels which, in the fœtus, carry the blood to the envelopes, and chiefly to the placenta. It is divided into two portions—an *amniotic*, the longest, which is always twisted on itself like a cord, and covered externally by the amnion that is prolonged on its surface, to be continued with the skin around the umbilicus; the other—the *allantoid* portion (Fig. 557, *B*)—much shorter and less twisted, is enveloped by the sheath that continues the two layers of the allantois, and is inserted into the superior wall of the chorion, between the two cornua.[1]

Three vessels compose the cord—two *arteries* and a *vein*; these are covered by a layer of embryonic tissue—the *gelatine of Wharton*—which makes them appear much larger than they really are.

The Umbilical Arteries[2] arise from the internal iliac, and pass along the sides of the bladder; escaping by the umbilicus, they arrive at the terminal extremity of the amniotic portion of the cord, and giving off some branches to the amnion, they are continued to the extremity of the allantoid portion, where they end in an expansion of placental ramifications. These arteries run parallel to the median plane of the body of the fœtus, to the umbilicus; they are perpendicular at the infundibulum, which proves that the allantois undergoes a twist in the early period of development. The *amniotic divisions* of these arteries are few, and extremely flexuous; they are included between the allantoid layer and the amniotic membrane, within which they may be seen projecting.

Fig. 560.



PORTION OF ONE OF THE FŒTAL VILLI, ABOUT TO FORM PART OF THE PLACENTA (HIGHLY MAGNIFIED).

a, *a*, Its cell covering; *b*, *b*, *b*, its looped vessels; *c*, *c*, its basis of connective tissue.

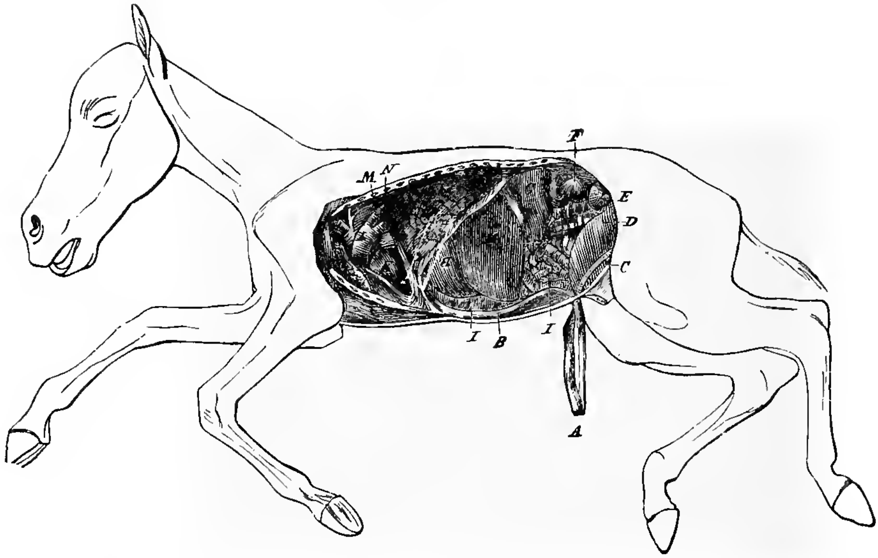
The *placental* or *chorial divisions*—infinitely larger and more numerous—leave the end of the cord, and pass in every direction between the chorion and external lamina of the allantois, beneath which they are very prominent. By their anastomoses they form a very rich network, from which proceed the capillary twigs that enter the villosities of the placenta. Observation demonstrates that these twigs do not communicate with the maternal vessels, and that they are continued by venous radicles, the origin of the vessel now to be described.

The Umbilical Vein commences by these capillary radicles of the placental villi, which unite between the chorion and amnion to form a network of more voluminous divisions and complexity than that of the arteries. Two principal

[1] Goubaux has remarked that the relations between these two portions are not constant. In a six months' fœtus, the amniotic part measured ·40 m., and the allantoid part ·24 m. In a fœtus of ten months, the first was ·30 m. long, and the second ·20 m.

[2] The walls of the umbilical artery are very rich in muscular fibres, which are longitudinal and transversal, but are irregularly distributed. There is no internal elastic tunic in any of the branches external to the umbilicus.

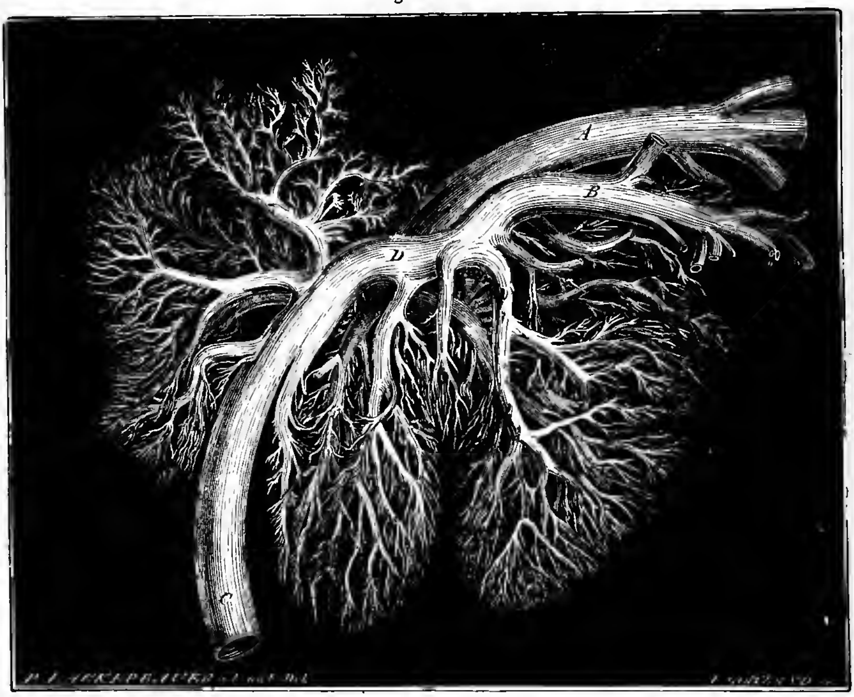
Fig. 561.



A FŒTUS OPENED ON THE LEFT SIDE TO SHOW THE COURSE OF THE UMBILICAL VESSELS IN THE BODY.

A, Umbilical cord; *B*, umbilical vein; *C*, umbilical artery; *D*, bladder; *E*, testicle; *F*, kidney; *G*, spleen; *H*, liver; *I*, intestine; *J*, lung; *K*, heart; *L*, pulmonary artery; *M*, ductus arteriosus; *N*, thymus gland.

Fig. 562.

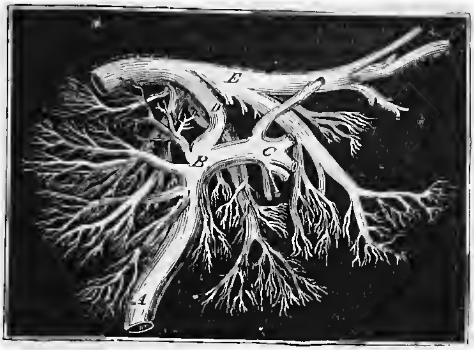


BLOOD-VESSELS IN THE LIVER OF AN EQUINE FŒTUS AT MID-TERM.

A Umbilical vein; *B*, its anastomoses with the portal vein, *C*; *D*, ductus venosus; *E*, posterior vena cava.

branches are, finally, the result of the coalescing; and these soon unite into a single trunk, which accompanies the two arteries in the cord. On reaching the umbilicus, this, the *umbilical vein* (Fig. 561), bends forward on the inner face of the abdominal parietes, where it is covered by the peritoneum, and arrives at the liver, into which it enters and opens directly into the vena portæ; the junction of the two vessels giving rise to a single canal, from which proceed the sublobular veins (Fig. 562). In other animals than Solipeds, this single vessel gives off a particular trunk of somewhat considerable volume, which passes directly to the posterior vena cava, and forms what is named the *ductus venosus of Arantius* (Figs. 562, 563).

Fig. 563.



LIVER OF A LAMB AT BIRTH.

A, Posterior vena cava; *B*, vena portæ; *C*, umbilical vein; *D*, anastomosis of the umbilical vein with the vena portæ.

Such are the umbilical vessels, and it will be seen that they form a part of the circulatory system of the young creature, which will be more completely studied hereafter.

Differential Characters in the Annexes of the Fœtus of the other Animals.

1. Ruminants.—*Placenta.*—The placental apparatus of the **Cow** is not uniformly spread over the outer surface of the chorion, but is constituted by a variable number of vascular bodies—about sixty on an average—disseminated here and there, and dovetailed by reciprocal penetration of prominences and cavities, into analogous bodies on the inner surface of the uterus, designated *cotyledons*. These are only thickened points of the mucous membrane, the follicles of which are enormously enlarged. They exist, we have seen, before gestation; but observation demonstrates that they may be afterwards formed or entirely renewed, especially in those cases in which accidental circumstances have rendered those present insufficient for their office. The largest are found in the body of the uterus; in the cornua they are smaller as they are nearer the extremity. Their form is generally elliptical, and they are attached to the uterine surface by a wide mucous pedicle; their surface is convex, and perforated by numerous openings, into which the placental tufts pass. They have always a yellowish colour, which, added to their external characteristics, gives them the appearance of a moril mushroom.

With regard to the *placentæ*, they repeat, on the surface of the chorion, the disposition of the cotyledons on the uterus. They are vascular, concave patches, closely embracing the cotyledons, and showing on their surface a multitude of long ramifying papillæ, which bury themselves in the cotyledonal cavities. They are attached to the chorion by a very thick, short, vascular pedicle.

In the **Sheep** and **Goat**, the arrangement is the same, except that the cotyledons are hollowed out in their centre, like a cup, and into this cavity the placentæ are inserted (Fig. 565).

Chorion.—The primary chorion disappears at the same time that the amnion is formed, and it is completely replaced by the definitive chorion towards the twentieth day, in the fœtus of the Sheep. The general form of this sac is an exact repetition of that of the uterine cavity. This membrane responds to the inner face of the uterus, in the interplacental points. These points constitute the *chorion* (or *decidua*) *serotina*, and the part carrying the placentæ is named the *chorion frondosum*. The inner face of the chorion is united to the amnion and the allantois by means of inter-annexial laminated tissue.

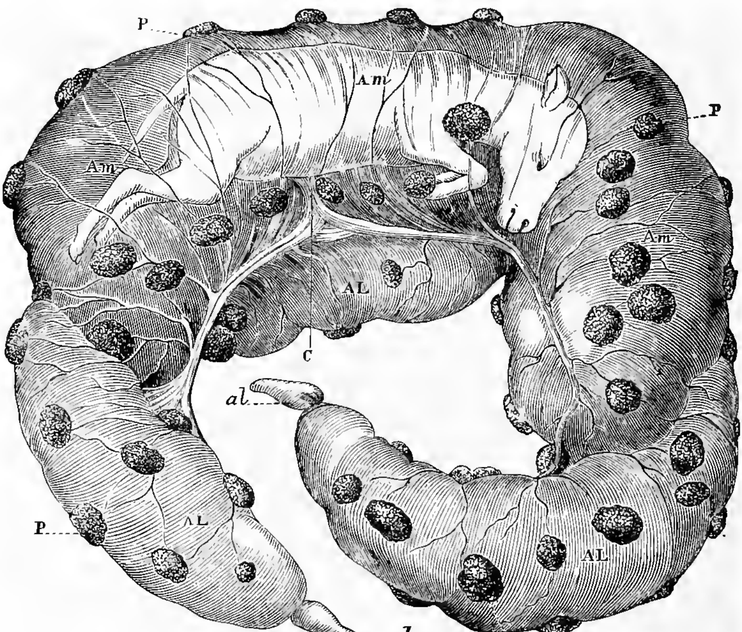
Allantois.—Very different from that of the Mare, and otherwise much less complicated, the allantois of Ruminants is a very elongated cavity, the middle portion of which receives the insertion of the urachus, and its extremities are prolonged into the two cornua of the chorion. This sac, which is an expansion of the urachus, is always reversed on one of the sides of the amnion; its two branches are sacculated on their surface like the large intestine, and the greatest forms a *cul-de sac.* or conical diverticulum.

The extremities of the allantoid cornua appear to have pierced the chorion; they form a point covered with a yellow, mucus substance, and separated from the rest of the membrane by a circular constriction. This part is beneath the chorion, like the remainder of the membrane, only the vessels do not extend beyond the constriction; so that the elements of the chorion and allantois here undergo a kind of mortification. The allantoid infundibulum is encircled by a vascular network that accompanies it throughout the umbilical cord.

The epithelium of the allantois is everywhere colourable by iodine reagents, in Ruminants. At times the hippomanes is found floating in the liquid it contains.

Amnion.—Altogether like that of Solipeds, this membrane is readily resolved into two

Fig. 564.



FŒTUS OF THE SHEEP, FREED FROM ITS CONNECTION WITH THE UTERUS.

AL AL, Allantois slightly inflated, seen beneath the chorion; *Am Am Am*, amnion slightly distended with fluid underneath the chorion; P, P, P, placentæ on the surface of the chorion; C, umbilical chord; *al*, *al*, extremities of the allantoidean cornua, looking as if protruding through the chorion.

laminæ, and presents on its inner surface a great number of little, yellowish-white, epidermic patches, more especially visible on the amniotic covering of the cord. The epithelium is only stained by iodine at these patches, or villi. These productions are surrounded at their base by a girdle of glycogenic cells. In the fœtus of the Cow, at a late stage of gestation, the amniotic fluid is not abundant, and becomes white and viscid; in one instance we found it stringy, like a solution of gelatine.

Umbilical cord.—This comprises two arteries and two veins; the latter forming one trunk on their entering the abdomen. To reach the chorion, these vessels only traverse the amniotic cavity. They are accompanied by the urachus, which at their extremity presents the dilatation that results in the allantoid sac.

Umbilical vesicle.—This pouch disappears at an early period, and not a vestige of it is to be found after the formation of the abdominal parietes.

2. Pig.—The *placenta* is formed by an expansion of the villous tubercles, as in Solipeds. The chorion is not entirely covered by these tubercles, but here and there it shows bright little patches, where its tissue is merely covered by an epithelial layer; it is also glabrous at those points where it is in contact with the chorion of neighbouring fœtuses.

The *chorion* has not a body and two cornua, but is merely an elongated sac, the two extremities of which are in relation with the adjacent fœtuses. The inner face corresponds, as in Ruminants, with the amnion and allantois. The latter is the same as in the Cow, though it is very much shorter; the inner covering of this membrane contains the glycogenic matter, but that of the amnion has none.

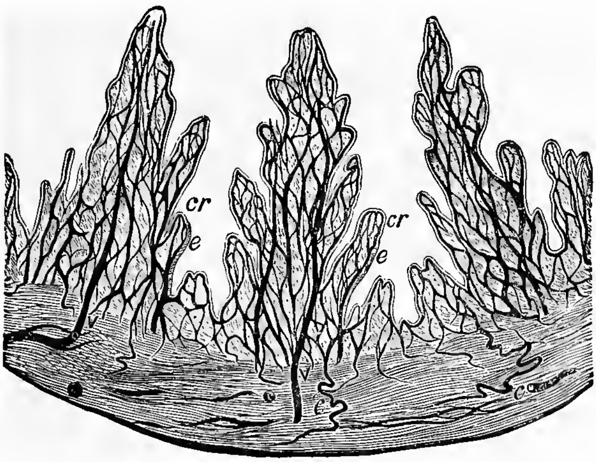
The *umbilical vesicle*, *amnion*, and *cord*, are also the same as in Ruminants.

3. Carnivora.—The *placenta* is a thick girdle, surrounding the middle portion of the chorion. It has a livid colour in its middle, green on its borders. When the green-coloured matter is isolated, and treated with alcohol and chloroform, then submitted to certain reagents, it appears to be identical with the colouring matter of the bile, and derived, as that is, from the hæmoglobin of the blood.

The *allantois* is disposed, in principle, as in Solipeds.

The *chorion* is quite like that of the Pig with regard to form, but it is different with regard

Fig. 565.



SEMI-DIAGRAMMATIC VERTICAL SECTION OF A MATERNAL COTYLEDON OF THE SHEEP.

(*cr*, Uterine sinus; *e*, epithelial lining of the sinus; v, veins, and *c*, flexuous arteries of the sub-epithelial connective tissue.

to structure, as it has no chora' plates with mineral granules. Nothing is known as to the organ which fulfils the function of these deposits.

The *umbilical vesicle*—which remains very developed at all periods of fœtal life—resembles in shape the allantois of the Pig, being a transversely elongated sac included between the amnion and the inner allantoid lamina, and provided at its middle portion with a narrow pedicle, which is prolonged into the umbilical cord; its walls are extremely vascular.

The *amnion* is lined, internally, by the inner lamina of the allantois.

The *umbilical cord* has, as in Solipeds, an allantoid portion; but it is extremely short, and enveloped in a wide fold of the allantois.

Results.—The comparative examination of the disposition of the placenta may furnish valuable indications as to the procedure to be adopted in practising artificial delivery; as the surgical manœuvres should necessarily vary with the extent and disposition of the points of union existing between the uterus and the fœtal envelopes.

With this practical object in view, we believe that it is useful to divide the domesticated animals into two groups: those which have a *simple*, and those which have a *multiple placenta*. The first group may be subdivided, according as the simple placenta is *general* or *local*.

This division is summed up in the following table:—

Animals	Simple placenta	Diffuse	Mare. Sow.
		Local and circular .	Bitch. Cat.
	Multiple placenta	Convex cotyledons .	Cow.
		Concave cotyledons	Sheep. Goat.

Comparison of the Annexes of the Human Fœtus with those of Animals.

The human fœtus, like that of the domesticated Mammals, is enveloped by an *amnion* and *chorion*, which are generally identical in disposition with those already described. The *umbilical vesicle* submits to the same change as in the Mare, becoming so quickly atrophied that scarcely any traces of it can be found at birth. It is impossible to isolate the *allantois* from the inner face of the amnion and chorion; so that some anatomists only admit its presence by analogy with what is observed in animals.

The *umbilical cord* offers nothing particular. The *placenta* is circular; its diameter at the termination of pregnancy being from 6 to 8 inches, and its thickness from 1 to 1½ inch. There is distinguished the *fœtal placenta*, to the midst of which the umbilical cord reaches; and the *maternal placenta*, the villi of which dovetail with those of the former.

The insertion of the placenta takes place towards the fundus of the uterus, near one of the Fallopian tubes. When there are more than one fœtus, there is a corresponding number of placentas.

Independently of those annexes—which are the same in all—there is described for the human fœtus a special envelope, external to the chorion—this is the *membrana decidua.* This is formed by the hypertrophied mucous membrane, which is doubled around the ovum, when the latter is lodged in the uterine cavity. Consequently, there results the division of the decidua into two parts—the *true decidua* (*decidua vera*) which covers the uterus, and the *reflected decidua* (*decidua reflexa*) which envelops the chorion. These present the characters of the hypertrophied uterine mucous membrane.

CHAPTER III.

DEVELOPMENT OF THE FŒTUS.

In the two preceding chapters, we have seen how the fecundated ovum is modified to furnish the earliest lineaments of the fœtus and the organs annexed to it; this chapter will be devoted to an examination of the manner in which the fœtus is developed, though this subject more properly belongs to physiology.

The young creature is designated an *embryo* during the early period of gestation, before it has assumed any definite shape; but as soon as it exhibits the form of the species to which it belongs—and particularly when the placental circulation is established—it is named *fœtus.*

Gurlt has divided the duration of gestation into seven periods, the length of which varies according to the species. He has also measured the dimensions of the ovum, the embryo, and the fœtus of each of them. We may, therefore, accept the figures he has given in order to learn the age of the fœtus. They are shown in the two following tables:—

DURATION OF THE PERIODS OF GESTATION.

Periods.	Mare.	Cow.	Sheep and goat.	Sow.	Bitch.
First	Two weeks.				
Second	Third and fourth week	Third and fourth week	Third and fourth week	Third and fourth week	Third week.
Third	From the fifth to the eighth week	From the fifth to the eighth week	From the fifth to the seventh week	From the fourth to the sixth week	Fourth week.
Fourth	From the ninth to the thirteenth week	From the ninth to the twelfth week	From the seventh to the eighth and ninth weeks	From the sixth to the eighth week	Fourth week.
Fifth	From the fourteenth to the twenty-second week	From the thirteenth to the twentieth week	From the tenth to the thirteenth week	From the eighth to the teoth week	Sixth week.
Sixth	From the twenty-third to the thirty-fourth week	From the twenty-eighth to the thirty-second week	From the thirteenth to the eighteenth week	From the eleventh to the fifteenth week	Seventh and eighth weeks.
Seventh	From the thirty-fifth to the forty-eighth week	From the thirty-third to the fortieth week	From the nineteenth to the twenty-first week	From the fifteenth to the seventeenth week	Ninth week.

DIMENSIONS OF THE OVUM, OR FŒTUS.

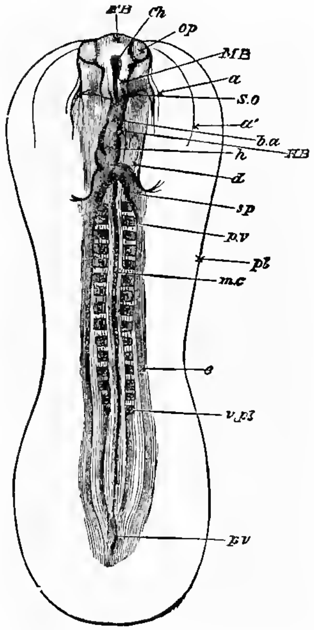
Periods.	Mare.	Cow.	Sheep and goat.	Sow.	Bitch.
First	The impregnated ovum has an average diameter of 2.256 mm.				
Second	13·535 mm.	9·023 mm.	10·151 mm.	10·151 mm.	4·512 mm.
Third	51 mm.	48 mm.	34 mm.	48 mm.	24 to 27 mm.
Fourth	162 mm.	149 mm	94 mm.	81 mm.	68 mm.
Fifth	352 mm.	320 mm.	162 mm.	135 mm.	94 mm.
Sixth	650 mm.	650 mm. (about)	325 mm.	189 mm.	135 mm.
Seventh (birth)	1137 mm.	812 mm.	490 mm.	243 to 270 mm.	162 to 221 mm.

The following are the weights of the completely developed fœtuses.

The *weight* of the fœtus of the Mare, at birth, varies according to breed. It has been found to be 35 pounds in a Corsican Mare, and 135 pounds in a Suffolk-Boulonnaise Mare; and between these extremes are many intermediate weights. In Cattle, the weight of the Calf is, on an average, 2·31 parts that of the Cow.

According to Leuckart, the weight of the Puppy at birth is about one pound; that of the Lamb, ten or eleven pounds; that of the Pig, five pounds; that of the Chick, about one and a half ounce.

Fig. 566.



EMBRYO OF THE CHICK AGED ABOUT THIRTY-SIX HOURS (INFERIOR FACE).

FB, Anterior brain, on the sides of which are seen the optic vesicles, *op*; *s.o*, posterior limit of the fold of somatopleure; *HB*, posterior brain; *MB*, middle brain; *p.v.* and *v.pl*, protovertebræ; *ch*, anterior extremity of the notochord; *pl*, outline of the area pellucida; *pv*, primitive trace.

The transition between the embryonic and the fœtal condition being inappreciable, we will study the first phases of development under the heading of formation of the embryo, and the last under that of the development of organs.

Article I.—Formation of the Embryo.

When the embryo has assumed the form of an elongated streak, and shows in its centre the primitive groove, there appear in the middle lamina of the blastoderm the *chorda dorsalis*, the *vertebral laminæ*, and the *lateral laminæ*.

Development of the Chorda Dorsalis and Vertebral Laminæ.

The *chorda dorsalis* is a cylindrical cord, slightly attenuated at both extremities, which is developed beneath the primitive groove. On its sides is a series of small, opaque, quadrangular masses—the *vertebral laminæ*—which are nothing more than the *protovertebræ*, or first traces of the fœtal vertebræ. They appear in the embryo, on each side of the neural axis, in the form of dark quadrilateral spots, and are developed in a series in the spinal zone.

They are hollowed by a central cavity, towards which converge a radial series of cells. On their lateral surfaces they are continuous with the musculo-cutaneous and fibro-intestinal laminæ, by means of an intermediate part—the *intermediate cellular lamina*.

At the third day they give rise, by differentiation, to the *muscular laminæ* (Fig. 567, *m.s.*). The protovertebræ afterwards become fused, and invest all the neural tube and the chorda dorsalis; and it is in this homogeneous matrix that an ulterior segmentation marks the traces of the definitive vertebræ. The articular intervals in the latter correspond to the middle portion of the proto-vertebræ.

The *muscular laminæ*, in augmenting in volume, are inflected upwards, and unite in the middle line of the back. They form, in great part, the muscles of the vertebral furrows; they also give off, below, prolongations which concur in the development of the intercostal and abdominal muscles, as well as those of the extremities.

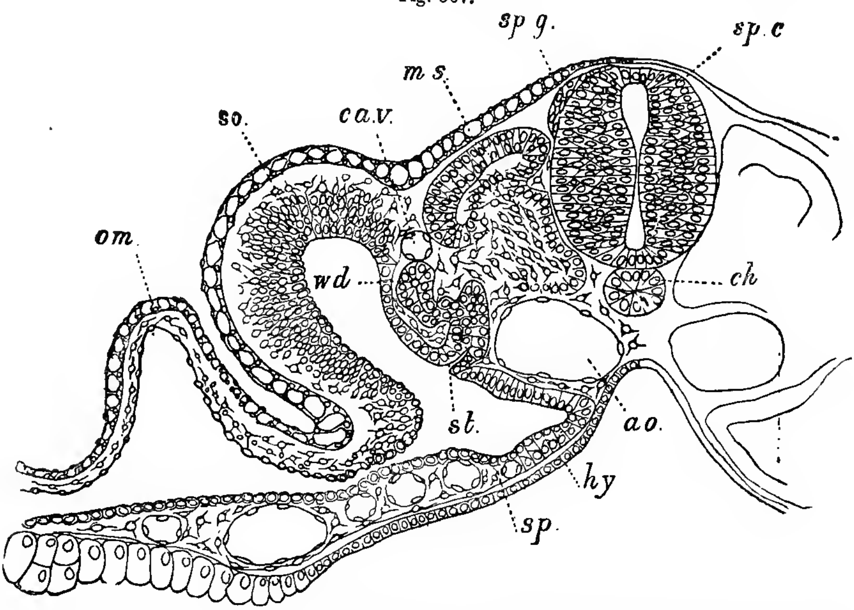
ARTICLE II.—DEVELOPMENT OF THE VARIOUS ORGANS IN THE ANIMAL ECONOMY.

Development of the Nervous System.

We will at first glance at the development of the nervous centres—the *brain* and *spinal cord;* then their peripheral parts—the *nerves.*

1. *First differentiations of the neuraxis.*—The trace of the central nervous system or neuraxis, resides, or has been seen, in the primitive groove, resulting from an inflection of the thickened ectoderm (Fig. 551). The complete invagination of the ectoderm brings about the formation of a tube—the neural *canal* (Fig. 552). From the thirty-sixth hour, the medullary laminæ are close to each other in front in the middle line, but are not yet fused together. From

Fig. 567.



TRANSVERSE SECTION OF THE BODY OF AN EMBRYONIC DUCK, THREE DAYS OLD. (AFTER BALFOUR.)
om., Amnion; *so.*, somatopleure; *sp.*, splanchnopleure; *wd*, Wolffian canal; *st.*, segmentary tube; *ca.v.*, cardinal vein; *m.s.*, muscular lamina, or plate; *sp.g.*, spinal ganglion; *sp.c.*, spinal cord; *ch.*, notochord; *ao.*, aorta; *hy*, endoderm.

the fortieth hour, the neural *canal* is closed as far as the *rhomboidal sinus*—the lozenge-shaped space where the primitive groove is widest.

Towards its anterior part, the neural canal shows three successive dilatations—tracts of the brain, and constituting the three primitive cerebral vesicles. The remainder of the neural canal forms the spinal cord.

2. *Development of the brain.*—The cerebral vesicles—at first three in number, and distinguished as anterior, middle, and posterior—soon undergo an increase to five.

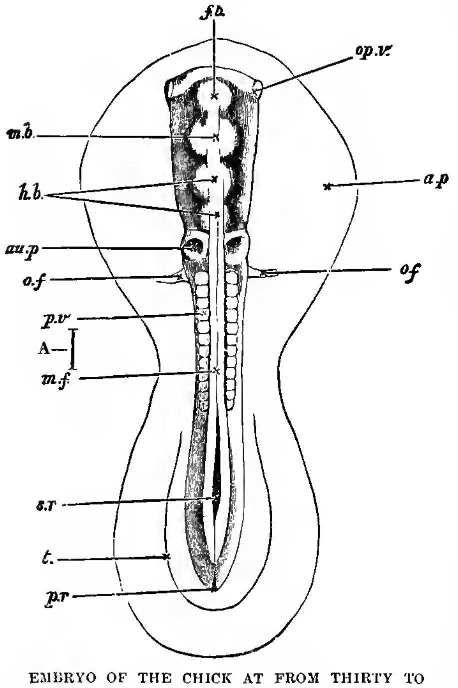
The anterior cerebral vesicle throws out two hollow prolongations which become the cerebral hemispheres, and now constitute the anterior brain. On the other hand, the anterior cerebral vesicle itself becomes the vesicle of the optic thalami, or intermediate brain (see Fig. 568).

The middle cerebral vesicle gives origin to the cerebral crura, the corpora quadrigemina, and the aqueduct of Sylvius or middle ventricle. It deserves to be named the vesicle of the corpora quadrigemina of the middle brain.

The third vesicle becomes doubled, forming the *cerebellar vesicle*, or *posterior brain*, from which arises the cerebellum, and the vesicle of the medulla oblongata which originates that body.

The middle vesicle is that which, at first, increases most rapidly in volume; it soon, however, ceases to grow, in order to allow the anterior cell to become developed, when the brain assumes its ovoid form, with a predominance of the anterior part.

Fig. 568.



EMBRYO OF THE CHICK AT FROM THIRTY TO THIRTY-SIX HOURS.

f.a, Anterior brain; *m.b*, middle brain; *h.b*, posterior brain; *op.v*, optic vesicle; *du.p*, olfactory fossa; *o.f*, vitelline vein; *p.v*, protovertebræ, or mesoblastic somite; *m.f*, line of junction of the medullary laminæ above the neuraxis; *s.r*, rhomboidal sinus; *t*, caudal fold; *p.r*, remains of the primitive groove; *a.p*, area pellucida.

Towards the end of the first third of intra-uterine life, nearly all the parts of the brain are distinct: the two hemispheres have become isolated by the development of the septum lucidum; the convolutions appear on their surface; and the corpora quadrigemina and cerebral cura are distinctly defined. It is not until a little later that the cerebellum is distinguishable, as well as the pons Varolli, medulla oblongata, corpora restiformia, and corpora pyramidalia.

3. *Development of the spinal cord.*—The neural canal is the first trace of the spinal cord; it occupies the whole length of the vertebral spine, and its cavity communicates, in front, with the fourth ventricle. When the spine is developed, the cord does not increase proportionately in length, and appears to ascend in the vertebral canal; it stops about the middle of the sacrum in the equine fœtus, but ascends higher in the other species. During this apparently ascensional movement is developed the *filum terminale*, and the nerves of the *cauda equina*.

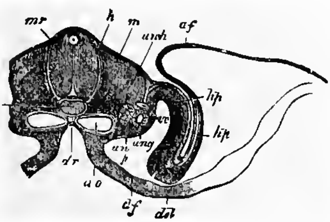
The walls of the neural canal, at first very thin, increase in thickness by the appearance of the nerve of the cord. Soon they divide into two layers—an internal, the *epithelium* of the central canal; the other external—the *grey substance* of the cord. Gradually the canal contracts, and the marrow is seen, with its longitudinal furrows.

At the end of the first month, the inferior roots are in existence, as well as the spinal ganglia; the latter are developed at the expense of the protovertebræ, as will be shown presently. The superior roots are formed some time afterwards.

The *envelopes* of the cerebro-spinal centres are furnished by the protovertebral laminæ; they are developed after the sixth week, progressing with the growth of the parts they are destined to cover.

4. *Development of the nerves.*—The development of the nerves is somewhat obscure. The motor roots seem to arise from the cord; but the spinal ganglia are formed separately in the protovertebræ, and perhaps originate the sensitive roots. The nerve-branches begin by elongated ramifying cells, which become fused to each other by their extremities—the nuclei of the cells lying at the periphery becoming the nuclei of the white substance of Schwann, the proper nerve-tissue being afterwards gradually deposited between the axis-cylinder and the envelope.

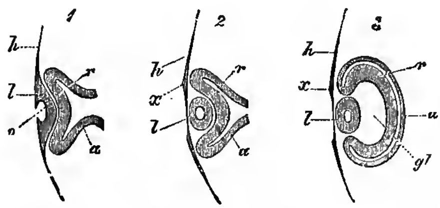
Fig. 569.



TRANSVERSE SECTION OF THE EMBRYO OF A FOWL AT THE BEGINNING OF THE THIRD DAY OF INCUBATION, × 90–100.

ch, Chorda dorsalis; *wwh*, position of a thinning, or cavity in the protovertebral mass, dividing it into an anterior and posterior portion; *hp*, parietal lamina; *df*, intestinal fibrous lamina; *dd*, intestinal glandular lamina; *dr*, primitive intestinal groove; *h*, corneal lamina; *mr*, medullary tube (spinal cord); *m*, muscular lamina; *p*, pleuro-peritoneal cavity; *af*, fold of the amnion; *ao*, primitive aorta; *vc*, vena cardinalis; *un*, Wolffian body; *ung*, duct of the Wolffian body.

Fig. 570.



LONGITUDINAL SECTION OF THE EYE OF EMBRYO FOWL.

1, From an embryo at about the sixty-fifth hour of incubation; 2, from an embryo a few hours older; 3, from an embryo at the fourth day of incubation. *h*, Corneal lamina; *l*, lens in fig. 1, still connected with the corneal lamina, and possessing a small cavity, o, in its interior (in figs. 2 and 3 it is seen detached, but still hollow); *r*, introverted portion of the primitive optic vesicle, subsequently becoming the retina; *u*, posterior part of the optic vesicle, which, according to Remak, probably becomes the choroid coat, ciliary processes, and iris, and in figs. 1 and 2 is still connected with the brain by the hollow optic nerve; *x*, thickening of the corneal lamina around the spot from which the lens has detached itself; *gl*, vitreous body, or humour.

The great sympathetic is early seen as a nodulated cord. It is probably developed in the same manner as the other nerves.

Development of the Organs of Sense.

The principal portion of the organs of sense belong to the dependencies of the nervous system, and are developed with it; the other parts belong to the external epithelial lamina, the skin, and the germinative lamina.

1. *Visual Apparatus.*—From the anterior cerebral vesicle are given off two tubular prolongations, which are directed forward, and terminate by the *primitive eye-vesicles*, traces of the ocular globes. The hollow protrusions form the optic nerves; the vesicles furnish the retina and choroid. The crystalline lens, vitreous humour, cornea, and sclerotica arise from the external blastodermic layer. These modifications take place in the following manner:—

The external integument of the fœtus passes over the front of the primitive eye-vesicles. Here it shows a slight depression on its outer surface, and on its inner face a cellular protrusion (Fig. 570, 1 *o*), which, becoming developed, surrounds the external depression, completely closes it, and constitutes the commencement of the *crystalline lens* (Fig. 570, 2 *l*). The latter, thus formed, presses on the primitive eye-vesicle, pushes it backwards (2), and gives rise to a *secondary eye-vesicle*, the anterior wall of which becomes the retina, and the posterior wall the choroid. The lens is, therefore, a dependency of the epithelial lamina; the cells composing it become elongated into fibres in the centre, and are disposed at its circumference as a primary amorphous envelope—the *crystalline capsule*—and afterwards as a secondary envelope rich in vessels.

The portion of the integument which is not doubled to form the lens envelops the globe, and gives rise to the *sclerotica* and *cornea;* the epidermis furnishes the epithelium of the latter, which becomes distinct from the sclerotica in the course of the fourth month.

An aperture—the *sclerotic cleft*—is made at the lower part of the fibrous envelope of the eye; this is connected with the development of the *vitreous body*—a prolongation of the derm—a kind of conjunctival bud passing through this opening, and placing itself between the crystalline lens and the anterior wall of the secondary eye-vesicle (3 *gl*), where it is developed and transformed into the vitreous body. At first it is encircled by vessels like the lens, but these disappear before the termination of gestation.

The *optic nerve* is developed in the pedicle uniting the eye-vesicle to the anterior cerebral vesicle. The *retina* is formed by the inner lamina of the secondary eye-vesicle; it extends to the lens in changing its character anteriorly. According to Remak, the *choroid* is constituted by the posterior lamina of the eye-vesicle; it advances at first to the lens, and then becomes inflected in front to form the *iris*. The borders of the pupil are attached to the vascular envelope of the lens, and this gives rise to the *pupillary diaphragm*, which disappears before birth.

The motor and protective organs of the eye are gradually developed around the globe. The *eyelids* are small cutaneous folds that appear towards the first third of uterine life; they increase, and unite at their margin until immediately before, or soon after birth, when they separate.

The *lachrymal gland* is a dependency of the epithelial lamina which is pushed in above the globe. At first solid, it gradually becomes channeled out by cavities, from which arise the excretory ducts.

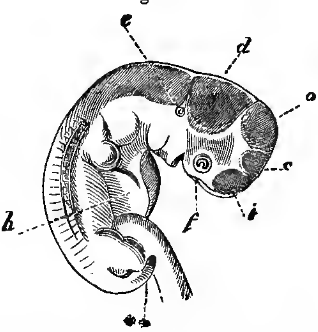
2. *Auditory Apparatus.*—The internal ear, auditory nerve, and middle ear, are developed separately. The *labyrinth* appears in the shape of a vesicle, which is not in direct relation with the posterior cerebral cell; it is constituted by a depression of the epidermic lamina—the *auditory fossa*—which is gradually developed, and at last becomes a closed cavity. At this time, the wall of the labyrinth is only a simple epithelial membrane; this is soon covered, outwardly, by a vascular connective membrane that separates into three layers—an internal, joined to the epithelium to form the membranous labyrinth; an external, that lines the cartilaginous labyrinth; and a middle, the soft, embryonic, connective tissue of which disappears, and is replaced by the *perilymph*. At the same time that these changes of structure are occurring, the vesicular form of the labyrinth is modified, and shows the *cochlea*, *semicircular canals*, *utriculus*, and *sacculus*.

The *middle* and *external ear* arise from the first pharyngeal (branchial) cleft, which is never completely closed, while the others disappear. At first, then, we find a cavity communicating externally with the pharynx; this cavity contracts, and is separated into two portions by a partition that spreads across its middle, and which becomes the *membrana tympani;* the internal portion is the *middle ear* and *Eustachian tube;* the external portion is the *external auditory canal.*

The *ossicula auditûs* appear in a cartilaginous state towards the third month; they gradually ossify, and have scarcely acquired their definitive volume at birth. The external ear (*concha*) is developed beneath the integument after the second month.

3. *Olfactory apparatus.*—This commences by two depressions of the epidermic lamina, analogous to the auditory fossa and that of the lens. These two olfactory fossæ appear below the ocular vesicles, and become more and more distinct, being margined by small projections which increase their depth. Behind, they communicate with the pharynx. The appearance of the palate separates them in front from the buccal cavity, and from this period the nasal fossæ are constituted. They are completed by the development of the bones of the face.

Fig. 571.



AN EMBRYO (HUMAN) OF FOUR WEEKS, ENLARGED ABOUT THREE TIMES.

a, Vesicle of corpora quadrigemina; *b*, vesicle of cerebral hemispheres; *c*, vesicle of third ventricle; *d*, vesicle for cerebellum and medulla oblongata; *e*, auditory vesicle; *f*, olfactory fossa; *h*, liver; **, caudal extremity.

The *olfactory bulbs* and *nerves* are primarily hollow, and joined to the anterior cerebral cell. The nostrils are formed, in the young fœtus, by a mass of mucus and epithelium; towards the middle of gestation they are open.

4. *Gustatory apparatus.*—See, subsequently, the *development of the tongue*, in *digestive apparatus.*

5. *Tactile apparatus.*—The *skin and its dependencies.*—The *skin* is developed at the expense of the epidermic lamina of the middle layer of the blastoderm. The cutaneous laminæ—by the modification of their elements—form the *derma*, in which the blood-vessels are very apparent at the third month. In the *epidermis*, the mucous and the horny layers are soon distinguished; in the first, the pigment is visible at the commencement of the fifth month in the larger Quadrupeds. When the fœtus increases in volume, the epidermis exfoliates, and its *débris* floats in the liquor amnii.

In the third month, the *hairs* are seen in the fœtus of the Mare and Cow; they appear at first on the eyebrows, lips, and the joints of the limbs; at the sixth or seventh month they cover the body. They may be shed and renewed before birth. They are developed in a prolongation of the epidermic lamina, which is embedded in the substance of the derm; it is shaped like a little bottle, and is composed of a mass of cells; in its centre, these cells are modified and collected together to form a small cone, the base of which covers the growing papilla. This cone becomes elongated, touches the surface of the epidermis, doubles under the effort to push through it, and finally makes its exit, after which it can grow freely.

The *sebaceous* and *sudoriparous* glands are developed in the same manner, towards the middle period of uterine existence.

"The horny productions—the *claws*, *hoofs*, *ergots*, *chestnuts*—begin to show themselves early. Towards the end of the second month, in the fœtus of the Cow, there is perceived, at the extremity of each limb, a small pale, translucid, conical tubercle, which is the rudiment of the hoof. At the commencement of the fourth month, or thereabouts, the hoof, better defined, has become firm and opaque, and has assumed a fine yellow tint. At mid-term, brown or black patches are manifest if the coronet is provided with pigment; it is only about the end of gestation that the hoof towards the coronet begins to have the greenish hue peculiar to horn destitute of pigment, but the remainder of this production—especially at the inferior part—preserves its yellow colour until birth. In Solipeds, the 'chestnuts' are shown at mid-term, in the shape of thin brown plates, which are soon darker-coloured."[1]

The horn of the hoof is not at first tubular; after birth it is shed, and is succeeded by a more consistent tubular horn, which had been forming beneath it.

Development of the Locomotory Apparatus.

1. *The Skeleton.*—We have seen at p. 19 how the development and growth of the bones take place; it is therefore needless to recur to this subject here; so we will limit ourselves to an examination of the mode of development of the principal sections of the skeleton.

A. *Development of the vertebræ.*—The vertebral spine is the first portion of the skeleton manifested in the embryo; it is represented by the chorda dorsalis

Fig. 572.

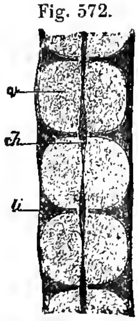


DIAGRAM SHOWING THE ATTENUATION OF THE CHORDA DORSALIS IN THE MIDDLE OF THE BODIES OF THE VERTEBRA, WHILST PRESERVING ITS ORIGINAL DIAMETER IN THE INTERVERTEBRAL SPACES.

ch, Chorda dorsalis; *v*, body of vertebra; *li*, intervertebral spaces.

Fig. 573.

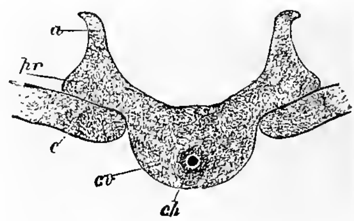


DIAGRAM SHOWING THE POSITION OF THE CHORDA DORSALIS IN THE BODY OF THE VERTEBRA, AND THE FORMATION OF THE NEURAL ARCHES.

ch, Chorda dorsalis; *cv*, body of the vertebra; *a*, neural arch, or neurapophysis; *c*, rib; *pr*, transverse process.

—a stalk constituted by a mass of cells situated in the interior of a transparent sheath. The *protovertebræ* appear on each side of the chorda dorsalis; in becoming developed, these parts encircle the latter and the medullary canal; from this results the *external theca of the cord*, and the *superior uniting membrane.* From this time, the vertebral column exists in the shape of a membranous axis.

Soon this membranous spine is segmented to give rise to the vertebræ, and its various portions gradually become cartilaginous. Each persistent vertebra does not exactly correspond to a protovertebra. In reality, the latter takes a share in the formation of two vertebræ, and divides into two portions—an inferior, which constitutes the posterior moiety of a permanent vertebra; and a superior, which forms the anterior moiety of the persistent vertebra immediately behind the preceding and the intervertebral disc.

[1] Colin, *Traité de Physiologie Comparée des Animaux*, 2nd Edition. Paris, 1873.

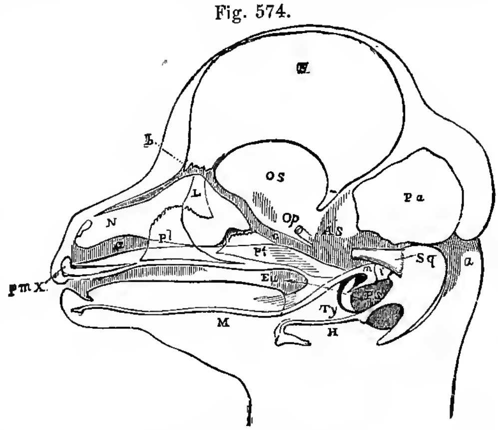
The bodies of the vertebræ are developed more rapidly than their spinal portion: thus, towards the end of the second month, all the vertebral bodies are already cartilaginous, while the vertebral laminæ are yet membranous. It is only in the third month that ossification begins in the vertebral column. The number of osseous nuclei—primary and complementary—is not the same in all species; they have been enumerated at p. 20. In a large number, the spinous process is regarded as the result of the joining together of the two moieties of the vertebral arch; in the Sheep, on the contrary, the spinous process forms a nucleus altogether independent of the vertebral arches. Thomas has noted this disposition, and he considers it as peculiar to animals the anterior dorsal vertebræ of which are furnished with a long spinous process.

During ossification, the chorda dorsalis disappears, except between the vertebræ, where it is developed to form the intervertebral substance or discs.

B. *Development of the cranium and face.*—The brain is enveloped by a membrane formed at the expense of the protovertebral laminæ. This *cranial membrane* becomes partly cartilaginous, partly fibrous; the cartilage exists at the base of the cranium, and seems to prolong the bodies of the vertebræ into this region; indeed it is known that the skull may be resolved into four portions, each corresponding to a vertebra. The cartilage is insensibly transformed into bone; while the fibrous part—comprising the roof of the skull and its lateral walls—passes directly into an osseous state.

The bones of the face are developed at the expense of the *pharyngeal arches.* This designation is given to four laminæ (or *lamellæ*) which spring from the anterior extremity of the chorda dorsalis, and double downward and inward to join those of the opposite side. They are also named the *branchial* and *visceral arches*, and the spaces between them are called the *pharyngeal clefts*. The upper jaw, mouth, nasal cavities: *i.e.* the nasal, maxillary, and palatine bones, are furnished by the first arch. Meckel's cartilage, which arises from the handle of the malleus to pass towards the inferior maxilla, is also a dependency of this branchial arch; it disappears towards the sixth or seventh month. It is to be remarked that, at the commencement, the mouth communicates with the nasal cavities; the palate is developed in two moieties which advance towards each other, though they remain a long time apart; so that at this time the young animal really has a hare-lip. The second pharyngeal arch forms the stapes, the pyramidal process of the temporal bone, the styloid arch, and the branch of the hyoid. The third develops the hyoid bone, with its cornua; while the fourth arch only constitutes the soft parts of the neck.

Fig. 574.



THE HEAD OF A FŒTAL LAMB DISSECTED TO SHOW MECKEL'S CARTILAGE.

M, Meckel's cartilage; *m*, the malleus; *i*, incus; *Zy*, the tympanic; H, the hyoid; *Sq*, the squamosal; *Pt*, pterygoid; *pl*, palatine; L, lachrymal; *pmx*, premaxilla; N, nasal sac, *Eu*, Eustachian tube.

The integument covering the pharyngeal bones is sometimes imprisoned at some points, when fusion of the bones of these arches occurs. There then result small dermoid cysts that slowly enlarge, and which the surgeon is sometimes called upon to remove from time to time, as they disfigure the face—if they have no other inconvenience.

C. *Development of the Thorax.*—The ribs are dependencies of the protovertebral laminæ, which curve towards the lower face of the vertebral column. The true ribs are most rapidly developed, and before attaining the middle line are united by their internal extremity, and form a moiety of the sternum. A fissure separates the costal arches of the right side from those of the left; this gradually contracts, and finally disappears, and the sternum is then formed. The ribs are, after the petrous bone, the parts of the skeleton which are most promptly ossified, ossification commencing in the middle ribs.

The costal arches do not belong exclusively to the dorsal vertebræ, but have a tendency to form along the whole length of the spine; and it is not rare to see—attached to the lumbar vertebræ—a small cartilaginous nucleus, which is soon lost in the texture of the abdominal walls. This nucleus assumes large dimensions on the last cervical vertebræ of Birds.

The form of the thorax varies with the species; in some it is circular, in others it is flattened laterally; and in all cases it is less developed in the fœtus and young animal than in the adult. It is in the latter that the thoracic cavity presents, proportionately, its greatest dimensions.

D. *Development of the Limbs.*—The limbs do not show themselves until after the formation of the spinal column, the pharyngeal arches, and the thoracic parietes. They appear as four little prolongations from the thorax and pelvis, and are slightly enlarged at their origin and constricted in the middle. Their free extremity is flattened, and either divides or remains single, as the animal has one or more apparent digits. It is in these prolongations that the cartilaginous segments are developed, which, at a later period, become the bones of the limbs. For the manner in which ossification is carried on in each bone, reference must be made to Osteology, Articles IV. and V., pp. 97 and 127.

2. *Muscles.*—The muscles are developed around the bones when these have become perfectly distinct. They may be divided into four groups—the *vertebral muscles*, which come from the muscular laminæ of the protovertebræ; the *visceral muscles*—thoracic and abdominal cavities, neck and jaw—having the same origin; the *cutaneous muscles*, which are developed at the expense of the cutaneous laminæ of the middle layer of the blastoderm; and the *muscles* of the limbs, the development of which is not yet perfectly known.

It was at one time believed that the muscular fibres were formed by the junction—end to end—of several elongated cells; but it is now known that they are constituted by a single cell which lengthens, and the nuclei of which multiply and lie at the surface, while its contents are transformed into a substance that offers the characteristics of contractile tissue. The sarcolemma is formed after the fibre, by a modification of the connective tissue surrounding it.

Development of the Circulatory Apparatus.

During the first days which follow the appearance of the embryo in the substance of the blastodermic layer, there is no trace of vessels in the area germinativa. It is not long, however, before the heart and some blood-vessels are seen in the middle layer, the vessels extending to the surface of the umbilical vesicle, which gradually shows itself. While the contents of the vitelline vesicle are undergoing absorption by the embryo, the heart is being completed, the vessels are developing, the allantois is formed, and the placental circulation—which continues until birth—is established. From this time the circulatory apparatus has acquired its definitive disposition.

1. *Appearance of the heart.—Circulation in the umbilical vesicle.*—The pleuro-peritoneal cavity of the embryo presents, anteriorly, a diverticulum—the *cardiac cavity*—in the interior of which the heart is developed.

From what has been already said, it will be understood that the circulatory apparatus is adapted to take the part, successively, of the umbilical vesicle and the placenta ; and from this two great systems arise—the umbilical or omphalo-mesenteric circulation, and the allantoid circulation.

As Dareste has it, the heart is primarily double. Its two portions are formed on each side by a folding inwards of the fibro-intestinal lamina and its endothelial lining. The two cardiac cavities open into each other by the absorption of the walls joined as a septum, and the simple heart assumes the form of a looped tube inclined to the right, as in Fig. 577.

As soon as it shows itself, the heart contracts and dilates alternately, the movements being very slow, though they gradually become quicker. Towards the twelfth day, the central organ of the circulation has the form of a contractile cylindrical tube. From its anterior part spring two branches—the *aortic arches* (*arcus aortæ*)—which are directed towards the head of the embryo, and are afterwards inflected downwards and backwards.

Fig. 575.

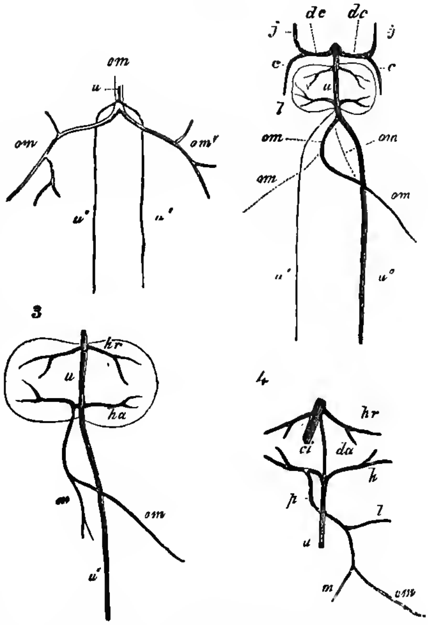


DIAGRAM OF THE FORMATION OF THE VENÆ OMPHALO-MESENTERICÆ AND UMBILICALES.

1, At the time of the first appearance of the umbilicales, and the commencement of the omphalo-mesentericæ ; 2, at the time of the first appearance of the branches to and from the liver, and the diminution of the omphalo-mesenteric vessels ; 3, 4, at the period of complete fœtal circulation in 1, omphalo-mesenteric trunk ; in 2, 3, remains of it ; in 4, vein of the yolk-sac alone ; *om'*, right, and *om''*, left vena omphalo-mesentericæ ; *u*, trunk of the umbilical vein ; *u'*, right, and *u''*, left vena umbilicalis ; *dc*, ductus Cuvieri ; *j*, jugularis ; *c*, cardinalis ; *l*, liver ; *ha*, hepatica advehentes ; *hr*, hepaticæ revehentes ; *m*, mesentericæ ; *da*, ductus venosus Arantii ; *ci*, cava inferior ; *p*, vena portæ ; *l*, lienalis ; *m*, mesenterica superior.

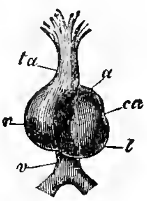
The aortic arches join together to constitute the *single aorta*, which, in its turn, divides into two trunks—the *arteriæ vertebralis*, or *primitive aortæ*. These vessels pass along the lower surface of the embryo, parallel to each other, and furnish during their course four or five divisions—the *omphalo-mesenteric arteries*—which ramify in the area germinativa, and open into a limitary vein named the *sinus* (or *vena*) *terminalis*. From the network of the area and the sinus arise two vessels—the *venæ omphalo-mesentericæ*—which enter the posterior extremity of the heart.

In Birds there are only two omphalo-mesenteric or vitelline arteries.

The circulation in the umbilical vesicle is somewhat ephemeral in several species, and it has been already stated that the vesicle is atrophied at an early period of fœtal life. In Birds it is most extensive; and its presence may be noted in the Carnivora during the whole term of uterine existence.

2. *Development of the heart and vessels.—Placental circulation.*—The *heart*, which, until now, was a cylindrical tube, is considerably modified before it attains its complete development. In its different phases, it successively offers all the forms known to exist in vertebrate animals. The first change consists in an inflection; the tube curves in an S-shaped manner, so that its inferior part becomes superior; it then dilates at three points: the anterior and superior dilatation situated at the origin of the aorta is named the *aortic bulb* (*bulbus aortæ*); the middle dilatation, the *ventricular cavity;* and the posterior dilatation, the *auri-*

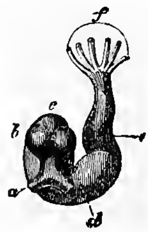
Fig. 576.



HEART OF THE EMBRYO OF A RABBIT, SEEN FROM BEFORE.

ta, Truncus arteriosus; *l*, left ventricle; *r*, right ventricle; *a*, auricle; *v*, venous sinus.

Fig. 577.



THE SAME, SEEN FROM BEHIND.

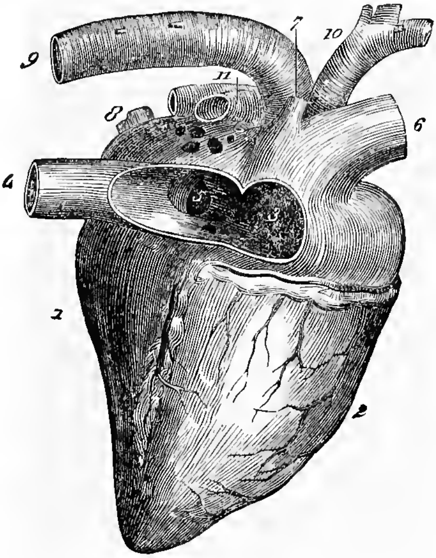
a, Venæ omphalo-mesentericæ; *d*, right auricle; *e*, bulbus aortæ; *f*, the six aortic arches; *c*, atrium; *b*, auriculæ.

cular cavity. *Haller's passage* is the name given to the constriction between the auricle and ventricle, which at this time are single. They do not remain long so, however. The ventricular cavity is the first to be divided into two compartments, and the division is marked externally by a groove which appears on the surface of the heart of the Ovine embryo towards the nineteenth day, and on the twenty-fifth in the Equine fœtus. This groove corresponds to an interventricular septum, which insensibly rises from the bottom of the ventricles; when it reaches the auricles, it concurs in forming the auriculo-ventricular openings.[1] The margins of these openings are provided with a small slightly salient lip, which afterwards, in developing, originates the mitral and tricuspid valves. The heart has now three cavities—two ventricles and an auricle; but in a brief period the latter is doubled, and the compartments are then four in number. Externally, there is observed a depression which shows the division in the auricles; at a point corresponding to it, a septum is developed in their interior which remains incomplete during the whole of fœtal life, being perforated by the *foramen of Botal.* With regard to the aortic bulb, it contracts and divides into two vessels—the aorta and pulmonary artery.

[1] This septum is sometimes arrested in its development, whence results an abnormal communication between the ventricles. Some instances have been given when describing the heart.

The *arteries* are developed partly at the expense of the vessels of the primary circulation, and partly in the vascular lamina of the embryo. The heart, when it was only a simple cylindrical tube, presented at its anterior extremity two aortic arches, which curved backwards and united to form the single aorta, then the vertebral or common aortæ. The aortic arches are situated at the inner face of the two first pharyngeal arches; afterwards more are developed, which are placed within the other pairs of arches, until the number is increased to five, though they never all exist at the same time. Some atrophy, while others are being developed: the two first entirely disappear; the third form the carotids; the fourth the axillary arteries and the arch of the aorta; the fifth atrophies on the right, and on the left originates the pulmonary artery, the ductus arteriosus, and the aorta. The latter is continued along the spine by the fusion of the two primitive aortæ. They present, at their posterior extremity, the pelvic vessels—which are very small—and the umbilical arteries, which are, on the contrary, remarkable for their volume.

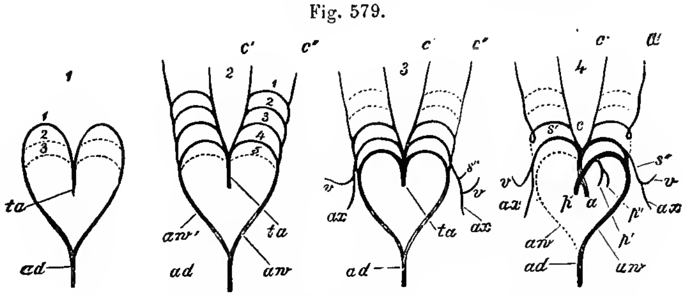
Fig. 578.



HEART OF AN EQUINE FŒTUS. THE RIGHT AURICLE AND POSTERIOR VENA CAVA HAVE BEEN OPENED TO SHOW THE FORAMEN OF BOTAL.

1, Left ventricle; 2, right ventricle; 3, interior of the right auricle; 4, posterior vena cava; 5, foramen of Botal.

Fig. 579.



PLAN OF THE AORTA AND ITS ARCHES AT AN EARLY PERIOD.

1, Truncus arteriosus, with one pair of aortic arches, and dotted lines indicating the position of the second and third pairs; 2, the same, with four pairs of aortic arches, and indications of the fifth; 3, the same, with the three posterior pairs of aortic arches, from which the permanent vessels of the embryo are developed, with dotted outlines showing the position of the two (now) obliterated anterior arches; 4, permanent arterial trunks in their primitive form, the obliterated portions still shown in dotted outline, 1–5, primitive aortic arches. *a*, Aorta; *p*, pulmonary artery; *p'*, *p''*, branches to the lungs; *aw'*, root of thoracic aorta (*ad*) on left side; *aw*, obliterated root springing from right side; *s''*, *s'*, subclavian artery; *v*, vertebral; *ax*, axillary; *c*, common carotid; *c'*, external carotid; *c''*, internal carotid.

The peripheral arteries arise, independently of the central vessels, on the interior of the vascular lamina. They appear in the form of solid cellular

Fig 580.

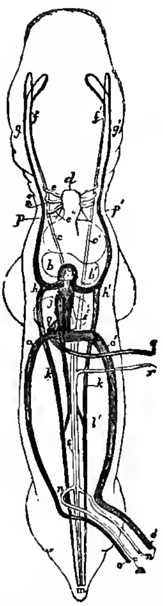


DIAGRAM OF THE CIRCULATION AT THE COMMENCEMENT OF THE FORMATION OF THE PLACENTA (SEEN FROM THE FRONT).

a, Venous sinus receiving all the systemic veins; *b*, right auricle; *b'*, left auricle; *c*, right ventricle; *c'*, left ventricle; *d*, bulbus aorticus, subdividing into, *e*, *e'*, *e''*, branchial branches; *f*, *f'*, arterial trunks formed by their confluence; *g*, *g'*, vena azygos superior; *h*, *h'*, confluence of the superior and inferior azygos; *j*, vena cava inferior; *k*, *k'*, vena azygos inferior; *m*, descending aorta; *n*, *n*, umbilical arteries proceeding from it; *o*, *o'*, umbilical veins; *g*, omphalo-mesenteric vein; *r*, omphalo-mesenteric artery distributed on the walls of the vitelline vesicle, *t*; *v*, ductus venosus; *y*, vitelline duct; *z*, chorion.

branches, which are hollowed in the centre by a cavity in which the cells become free. In proportion as these new vessels are developed, the omphalo-mesenteric vessels disappear, until at last there only remain one or two ducts that pass to the umbilical vesicle.

The *umbilical veins* are developed immediately after the formation of the omphalo-mesenteric veins; they enter the common trunk of the latter, and when its ramifications diminish in volume, the umbilical veins increase rapidly; when the liver is formed around them, they throw into it branches, which are the rudiments of the hepatic network. Between the hepatic and sublobular veins, the umbilical vein communicates with the vena cava by the *ductus venosus of Aranzi*, which, according to M. Colin, does not exist in the fœtus of Solipeds in the last moiety of uterine life.

The veins of the embryo form four principal trunks at first—two anterior, the *anterior cardinal veins;* and two posterior—the *posterior cardinal veins.* The veins of the same side unite in twos, from which result the *Cuvierian ducts ;* these open transversely into the omphalo-mesenteric trunk, close to the auricular cavity.

The anterior cardinal veins issue from the cranium; they form the jugular veins, and communicate by an anastomosis that extends transversely from left to right. Below this anastomosis, the left vein gradually atrophies, as does the Cuvierian duct of the same side; but the canal on the right side increases, and becomes the anterior vena cava.

The *posterior vena cava* appears behind the liver towards the fifth month; it receives the veins of the kidneys and Wolffian bodies, and, behind, it anastomoses with the cardinal veins. The latter disappear in their middle portion, and are replaced by the *vertebral veins*, the right of which forms the vena azygos. There only remain the two extremities of the cardinal veins; the anterior enters the Cuvierian duct, and the posterior constitutes the hypogastric and crural veins. From this disposition, it will be seen that at first the venous system of the fœtus is perfectly symmetrical, but that in the adult animal it becomes asymmetrical.

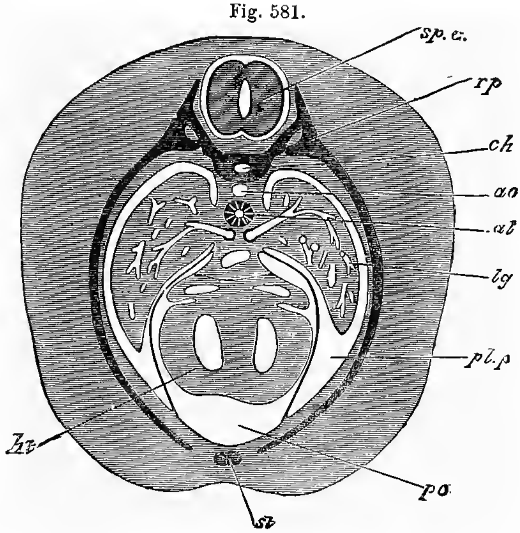
In consequence of these successive developments, the placental circulation is instituted, and continues the same until the termination of intra-uterine life. The heart is always the organ that propels the blood, and this passes into the arteries, reaches the umbilical arteries, and is carried to the placenta. There it is renewed—becomes *arterial* through contact with the maternal blood—and is returned by the umbilical veins. In the substance of the liver it is mixed with the venous blood of the intestines and posterior extremities, through the medium of the ductus venosus, and at last arrives at the right auricle, then passes into the right ventricle, from which it is propelled by a contraction.

Instead of going to the lungs—which do not yet act as respiratory organs—the blood, being pressed by the contraction of the right ventricle, passes into the aorta by the *ductus arteriosus.*

To sum up, the fœtus never receives pure arterial blood into its organs, this being always mixed with venous blood—the mixture taking place at several points : 1. By the foramen of Botal. 2. In the aorta by the ductus arteriosus. 3. In the liver by the ductus venosus. The head and neck are the parts which receive the purest arterial blood—a fact that explains the predominance of the anterior over the posterior portion of the body of the fœtus.

At birth, the conditions of existence being suddenly changed, marked modifications take place in the circulatory apparatus. The lungs become the organs of respiration, and rapidly increase in capacity; the pulmonary artery dilates to give passage to the blood that flows to them; while the ductus arteriosus is obliterated, in order to isolate the arterial from the venous blood. This separation of the two fluids also takes place in the liver by the atrophy of the ductus venosus, and in the heart by the occlusion of the foramen of Botal; though, according to Goubaux, that orifice frequently remains open in young animals. Its persistence has also been noted in the human adult. Notwithstanding the presence of this foramen, the circulation cannot be much disturbed; as when the heart contracts, the auricles become isolated by the constriction of the opening and the raising of a valve.

Fig. 581.



TRANSVERSE SECTION OF THE ADVANCED EMBRYO OF A RABBIT, SHOWING THE RELATIONS OF THE HEART WITH THE LUNGS AND DIGESTIVE TUBE.

ht, heart; *pc*, pericardial cavity; *pl.p*, pleural cavity; *lg*, lungs; *al*, digestive canal; *ao*, aorta; *ch*, notochord; *rp*, ribs; *st*, sternum; *sp.c*, spinal cord.

(Lymphatic vessels and glands are found at an early period of fœtal life, after the blood-circulation has been fully established. In connection with these should be mentioned the *prevertebral hæmo-lymph glands*, which are best observed, however, in the adult animal—and particularly in the Sheep and Ox. They are small oval or lenticular bodies, about the size of a mustard-seed, and are found in the abdominal and pelvic cavities among the fat and connective tissue, between the vertebral column and peritoneum, as well as in the thorax, in the middle and posterior mediastinum. They are larger in Oxen than Sheep; there are from three to four hundred in the latter. They are supposed to be the source of some, at least, of the lymphoid cells and non-nucleated and multi-nucleated corpuscles which occur in the blood.)

Development of the Respiratory Apparatus.

Observers are not unanimous as to the development of the *lungs*. According to Reichert and Bischoff, they arise from two small solid cellular masses lying on the surface of the anterior portion of the intestinal canal. These become channeled out into numerous ramifying cavities (by the deliquescence or fusion of the internal cells), which communicate with the trachea. Costa states that they commence by a median, bud-like, hollow process that opens into the œsophagus. The walls of the communicating aperture elongate considerably, and at a later period form the trachea and larynx; while the hollow bud divides into two pyriform sacs, each of which becomes broken up into a multitude of subdivisions to constitute the pulmonary lobes, with their vesicles and infundibula.

Fig. 582.

FIRST APPEARANCE OF THE LUNGS.

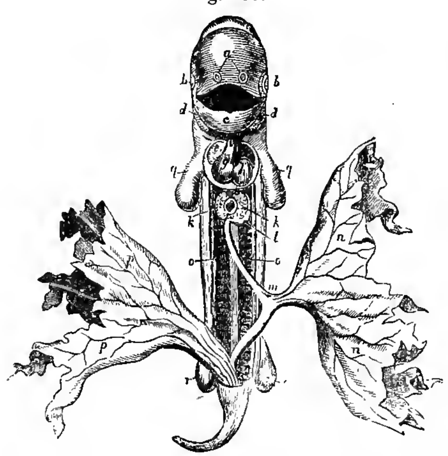
a, In a Fowl at four days; *b*, at six days; *c*, termination of bronchus in a very young Pig.

The *trachea* is completed by the development of the cartilaginous rings in the tube that binds the lungs to the œsophagus. They appear at the commencement of the third month.

The *larynx* is developed in the same manner at the pharyngeal opening. It is always somewhat undefined during youth, and its definitive volume is not acquired until the period of puberty.

The *thymus gland* appears as a process of the respiratory mucous membrane. It seems to be formed at the larynx, and gradually descends along the trachea to the entrance of the thorax.

Fig. 583.



EMBRYO OF DOG, TWENTY-FIVE DAYS AFTER LAST COPULATION.

a, *a*, Nostrils; *b*, *b*, eyes; *c*, *c*, first visceral arches, forming the lower jaw; *d*, *d*, second visceral arches; *e*, right auricle; *f*, left auricle; *g*, right ventricle; *h*, left ventricle; *i*, aortic bulb; *k k*, liver, between the two lobes of which is seen the divided orifice of the omphalo-mesenteric vein; *l*, stomach; *m*, intestine, communicating with the umbilical vesicle, *n n*; *o o*, corpora Wolffiana; *p p*, allantois; *q*, *q*, anterior extremities; *r*, *r*, posterior, extremities.

Development of the Digestive Apparatus.

In this paragraph, the development of the alimentary canal will be first studied, then that of the organs annexed to it.

A. **Alimentary Canal.**—We have seen how the embryo, in becoming incurvated, divides the blastodermic vesicle into two parts which communicate by a large pedicle. The external portion is the umbilical vesicle; the pedicle is the omphalo-mesenteric duct, and the inner part the intestinal cavity.

The latter may be resolved into three portions: the *anterior intestine*, which forms the pharynx and œsophagus; the *posterior intestine*, that gives rise to the rectum; and the *middle* intestine, which becomes the stomach and intestines.

The middle intestine appears at first as a uniform cylindrical tube, the diameter of which is afterwards modified to constitute the organs comprised between the œsophagus and rectum.

1. *Mouth.*—It begins by a depression limited by the maxillary buds. This blind pouch gradually enlarges inwardly, and proceeds to meet the pharynx, from which it is only separated, at a certain period, by a thin membrane; this is at last absorbed, and the two cavities then communicate. Until the third month, the mouth is confounded with the nasal cavities; at this time the palate appears, and this eventually isolates them.

2. *Tongue.*—Appearing at first as a small prominence on the maxillary buds, the tongue is completed by the addition to it of a bud from the second branchial arch. Its epithelium and glands come from the external blastodermic lamina; they are developed in the third and fourth months.

3. *Pharynx and œsophagus.*—These two organs become enlarged and elongated as the fœtus grows. The œsophagus communicates at first with the trachea; but it slowly closes, and finally separates completely from that canal.

4. *Stomach.*—This is formed by the dilatation of the anterior part of the middle intestine. The dilatation is fusiform, and its largest axis lougitudinal; it soon incurvates, and its longest axis is then transversal. In Ruminants, the stomach is at its first appearance simple; but before long it shows grooves on its surface, and in its interior septa, as in the normal state. During fœtal life this organ is small; but after birth, when solid food begins to be taken, it augments rapidly in volume. During lactation in Ruminants, there is remarked a predominance of the fourth over the other gastric compartments; but immediately the young animal commences to consume fibrous aliment, the rumen quickly increases in size, and it is not long before it becomes the most considerable division.

5. *Intestines.*—The intestinal tube is primarily of a uniform calibre, though in a short time there can be distinguished the various regions of which it is composed. According to A. Baer, the cæcum is early seen in hoofed animals, and is situated in the vicinity of the omphalo-mesenteric duct. This duct detaches itself from the extremity of an intestinal loop, which is drawn towards the umbilical ring; when the latter is becoming atrophied and progressing towards complete obliteration, this loop reascends into the abdominal cavity.

The intestines are smooth on their inner face during the first two months; but during the third they show their villosities and the glands of Lieberkuhn. The Brunnerian and solitary glands are a little later in showing themselves.

6. *Rectum.*—This is derived from the posterior intestine, and is developed like the other portions.

7. *Anus.*—Towards the caudal extremity of the fœtus is observed a depression, analogous to the buccal *cul-de-sac*. This gradually deepens, and is joined to the rectum and genito-urinary organs. Later, it is separated from the latter, and then belongs exclusively to the alimentary canal.

B. **Annexes of the Alimentary Canal.**—These are the salivary glands, teeth, liver, pancreas, and spleen.

1. *Salivary glands.*—These are developed in a solid cellular bud, which is related to the epithelium at the commencement of the digestive apparatus. This

bud increases, and at the same time is hollowed into glandular pouches. The submaxillary gland is the first to appear; according to Bischoff, it is entirely formed in the fœtus of a Cow only an inch in length. The parotid gland is the last to be formed.

2. *Teeth.*—These organs are developed in the interior of a cavity, named the *dental follicle* or *sac*, by means of the elements of three germs—one belonging to the ivory, another to the enamel, and a third to the cementum.

Follicle.—The *dental follicle* is an oval cavity, with walls composed of two layers; the external is fibrous and complete; the internal—soft or gelatinous—is allied at the bottom to the *ivory germ.* The latter is a prominence which is detached from the bottom of the follicle, and has the exact shape of the tooth. Its structure comprises, in the centre, delicate connective tissue provided with vessels and nerves, and on the surface a layer of elongated cells. At the summit of the follicle, facing the ivory germ, is the *enamel germ;* it is exactly applied to the dental pulp, which it invests like a cap, and is composed of a small mass of mucous connective tissue covered by a layer of cylindrical cells—the *adamantine tissue* of Renaut—joined to the buccal epithelium by the *gubernaculum dentis.* The *cementum organ* manifestly exists in the Foal, according to M. Magitot. The base of the ivory germ has been found, but it disappears rapidly after having performed its function.

How are the different parts of the dental follicle developed? When the maxillary arches are formed, the alveolar borders show a ridge which enters the embryonal tissue of the jaws. On the inferior border of this epithelial ridge are formed buds (enamel organs), in number equal to that of the temporary teeth —these are the primitive buds.

While these buds—dependencies of the octoderm—are developing towards the interior of the jaw, there appear the dental bulbs (ivory organs), which arise from embryonic tissue; these grow outwards and bury themselves in the summit of the enamel organs, so as to form a cap over them. Afterwards the wall of the dental follicle is detached from the base of the bulb, rises, and envelops the two germs in an oval sac.

Magitot and Legros have remarked in the embryo of a Mare that: 1. At the hundredth day, the enamel organs of the incisiors are distinct, and are detached from the epithelial layer; the follicles of the molars are in a slightly more advanced state. 2. At one hundred and ninety days, the incisor follicles are closed; the molars are almost in the same state. 3. At two hundred days, the follicles have attained their complete development—which precedes by some days the appearance of the dentine cap; the permanent incisor follicles are visible, but not yet closed. 4. At two hundred and twenty days the temporary follicles are very voluminous; the dentine cap is already considerable; and the two coronary and radicular cement organs are in place and quite developed.

Formation of the ivory, enamel, and cementum.—The ivory and enamel are developed by the modification of the elements situated at the surface of their germ.

It has been shown that the germ of the ivory, or dental pulp, had exactly the form of the future tooth; consequently the ivory which arises from its periphery offers the shape of this tooth. The *ivory* (*dentine*) is constituted by the cells of the germ, which elongate, send out prolongations—the *dental fibres* —that ramify and anastomose, and by an intercellular substance which is impregnated with calcareous matter, is moulded around these fibres, and forms the dental canaliculi.

The *enamel* is derived from the deep cells of its germ, which are elongated and prism-shaped, and are calcified on becoming applied to the surface of the ivory.

The *cementum* is developed at the expense of the walls of the follicle, according to the mode of ossification of the connective tissue.

Eruption.—As the ivory is formed, the tooth increases in length and presses the enamel germ upwards ; the latter, constantly compressed, becomes atrophied, and finally disappears when the tooth has reached the summit of the follicle. In the same way the young organ pierces the dental follicle and gum, and makes its eruption externally.

Such is the mode of development of the deciduous teeth. The permanent ones are formed in the same manner.

The enamel organ proceeds from a point adjoining the summit of the follicle of the temporary tooth, and buries itself beneath the latter, where it forms the dental bulb and the walls of the new follicle. The follicles of the three last molars—which are permanent—arise independently of those of the temporary teeth. The bud of the first of these molars springs from the epithelial ridge on the border of the jaws, the buds of the other two being derived from the first.

3. *The liver.*—This gland commences to be developed very early in all the species. It appears on the surface of the duodenum in the form of two or more buds, according to the number of lobules in the adult liver. To these external buds are corresponding internal ones, arising from the intestinal epithelium—that is, the inner lamina of the blastoderm. The first are contained in a layer of the mesoblast that separates the *anterior aditus* of the pericardium ; they grow and envelop the omphalo-mesenteric vein ; the second ramify in their interior, and form the system of biliary canals.

Fig. 584.

ORIGIN OF THE LIVER FROM THE INTESTINAL WALL IN THE EMBRYO OF THE FOWL, ON THE FOURTH DAY OF INCUBATION.

a, Heart; *b*, intestine; *c*, everted portion, giving origin to liver; *d*, liver; *e*, portion of vitelline vesicle.

The liver grows rapidly, and, towards the third month, almost entirely fills the abdominal cavity ; at a later period its growth is less marked, although at birth it is yet proportionally larger than in adult life.

4. *Pancreas.*—The pancreas first appear, like the salivary glands, in the form of a solid cellular bud, which afterwards is channeled into ramescent cavities.

5. *Spleen.*—According to Bischoff, this body is developed—during the second month—on the large curvature of the stomach. Arnold states that it is formed at the same time as the liver, in a strip extending from the stomach to the duodenum. It subsequently separates from the pancreas and becomes fixed to the stomach, where its elements assume the character of spleen-tissue.

Development of the Genito-Urinary Apparatus.

The development of the genital organs is related to that of the urinary organs, as the apparatus they form have some parts in common.

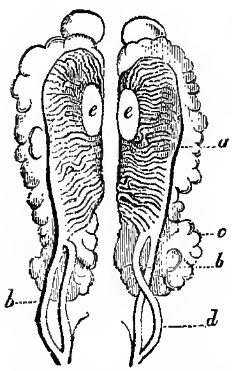
Immediately after the formation of the intestines, the genito-urinary organs are furnished by the Wolffian bodies. These—also named the *primordial kidneys* and *bodies of Oken*—are glandular in structure, and extend in front of the vertebral column from the heart to the pelvis. They are composed of small transverse canals, filled with a whitish fluid, which enter a common excretory duct that lies parallel to the spine, and opens inferiorly into that portion of the allantois which becomes the bladder.

The Wolffian bodies are placed behind the peritoneum, and are attached by two serous folds: an anterior—the *diaphragmatic ligament*—and a posterior—the *lumbar ligament of the corpora Wolffiana*. The organs furnish a liquid analogous to the urine; though it is not long before their secretion undergoes great modifications; indeed, these bodies soon atrophy, and disappear more or less rapidly, according to species. One portion serves for the development of the genital organs; the other gives rise to organs the signification of which is unknown—such as the organ of Rosenmüller—which is very developed in the Mare, and the canals of Gaertner, visible in the Cow and Rabbit (Mare and Pig).

A. **Urinary Organs.**—We have seen above how the allantois is derived from the blastodermic lamina; it has now to be stated that the *bladder* is derived from the allantois. This reservoir is the result of the dilatation of the abdominal portion of the allantois. During fœtal life, the bladder is extended, by the *urachus*, to the umbilical ring; but after birth the urachus is obliterated, and the bladder is withdrawn into the pelvic cavity. Hereafter we shall study the urethra.

The *kidneys* appear a long time after the Wolffian bodies, in the shape of two blind pouches constituted by a pushing back of the wall of the excretory duct of that body. These little *culs-de-sac* ramify, and are afterwards replaced by solid buds, in the interior of which are developed the uriniferous tubes and Malpighian bodies. According to certain observers, the kidneys subsequently communicate with the ureters, which are developed separately in the middle layer of the blastoderm (for further details, see Book IV., p. 573).

Fig. 585.



STATE OF THE GENITO-URINARY APPARATUS IN THE EARLY EMBRYO OF THE BIRD.

a, Corpora Wolffiana; *b*, *b*, their excretory ducts; *c*, kidneys; *d*, ureter; *e*, *e*, testes.

(In the female, the Wolffian bodies do not entirely disappear; the canals of Gaertner and the bodies of Rosenmüller, situated in the broad ligaments, between the ovaries and Fallopian tubes, are their remains in adult life; traces of them are also found in the male, near the head of the epididymis, where they constitute the *vasa aberrans* of the testicles. The *supra-renal capsules* are very large in the Equine fœtus, being nearly one-half the size of the kidneys.)

B. **Genital Organs.**—The genital apparatus of the male and female are at first very much alike; indeed, during a certain period it is impossible to distinguish the sexes; so that some authorities have proposed to term this period of development the "indifferent state of the genital organs." Later, the sexes are defined; and this period of development may be studied in the internal and external organs.

1. *Indifferent state of the internal genital organs.*—Towards the sixth week, there is observed on the lower face, and near the inner border of the Wolffian bodies, a little white cord, which increases in volume and maintains almost the same position. This new organ is the *genital gland*, which is attached to the

Wolffian body by serous folds, and is formed by a mass of young cells sustained by an enveloping membrane.

The development of this gland is accompanied by the formation of the *genital* or *Müller's duct*, which is seen to the inside, and in front of, the Wolffian duct. Müller's duct is at first a solid cellular column, which afterwards becomes a canal; it terminates above in a blind pouch, and opens, below, into the bladder, near the Wolffian duct, which is formed at the same time.

The stroma of the genital glands in the two sexes, is the seat of a differentiation that gives rise to a system of reticulated solid cords, called the *sexual cords*. Its surface is covered by an epithelium, which is continuous with that of the peritoneum, but so specialized here as to merit the name of *germ-epithelium*.

The sexual specialization is produced in the following manner:—[1]

a. In the male, by the evolution of the sexual cords, or tubuli seminiferi.

The testicle is completed by the annexation of the anterior region of the Wolffian body, which forms the head (*globus major*) of the epididymis, while the *tail* (or *globus minor*), *vas deferens*, and *ejaculatory duct*, are derived from the Wolffian duct. Lastly, the *vesiculæ seminales* and the *origin of the urethra* are formed by the posterior extremity of Müller's ducts, which join and open into the *uro-genital sinus*, as the very short canal is named which communicates between the bladder and cloaca.

The developed testicle remains in the abdominal cavity, or descends through the inguinal canal into the scrotum. The mechanism of this descent has been already explained.

(It may be necessary here to state that, in the Equine species, the testicles do not usually descend into the scrotum until some time after birth—about six months; while in other animals they reach that sac during fœtal life. In the Bovine species, the testes are in the scrotum about the twentieth week of gestation, and in the Sheep and Goat about the fifteenth week; indeed, it has been observed that in all Ruminants their descent is effected before the skin is covered with hair. In the Carnivora, they are usually in the scrotum a few days before birth.)

b. In the female, the sexual specialization is produced by a process of the germ-epithelium, which results in the establishment of an ovigenous layer. The *Fallopian tube* and its pavilion are formed by the anterior part of Müller's duct, the extremity of which shows a small linear orifice. The *uterus* and *vagina* arise from the posterior part of Müller's ducts. These lie beside each other, and end by joining behind to constitute a single canal; the two divergent portions of these canals comprised between the point of fusion and the Fallopian tubes form the uterine cornua.

The uterus and vagina are at first placed end to end, without any apparent

[1] At the same time that the sexual specialization of the genital gland is affirmed in the ovary and testicles, the glands themselves afford exact evidence of the opposed sexualities. In the testicles, the germ-epithelium is the seat of an evolution that gives rise to the primordial ova which Laulanie has observed in the fœtus of the Cat, measuring from ·7 to ·12 m. In the same animal species, this author has noted—with regard to the fœtal ovary—the connections between the primitive sexual cords and the tubes of the Wolffian body, establishing the homology of the first tubuli seminiferi. A demonstration has therefore been given for the first time, of a real organic hermaphrodism of the sexual glands, and from this arises the interesting notion that the sexuality of the individual has been preceded by a period of indifference and a period of bisexuality.

separation ; but towards the sixth month the neck of the uterus commences to be defined.

2. *Indifferent state of the external genital organs.*—The intestine is terminated by the *cloaca*—a cavity into which the digestive canal and bladder open by the uro-genital sinus. This confusion quickly ceases by the development of a transverse septum that divides the cloaca into two compartments—the *anal opening* and the *uro-genital aperture.* At the inferior end of the latter appears the *genital tubercle*—the rudiment of the penis or clitoris, and which is surrounded by cutaneous folds—the *genital folds.* This tubercle increases in volume, and has a furrow passing from behind to before. Up to this moment it is impossible to distinguish the sexes.

Development of the external genital organs of the male.—The male sex is marked by the rapid development of the genital tubercle, which becomes the penis—its extremity enlarging to constitute the glans. The genital furrow closes posteriorly, and forms the urethra. The genital folds draw towards each other below the penis, unite in the middle line, and thus produce the scrotum. Owing to these modifications, the digestive apparatus is completely separated from the genito-urinary organs, and the urethral canal is connected with the bladder and the excretory ducts of the testicle.

Development of the external genital organs of the female.—The indifferent state of the genital organs is readily succeeded by the feminine type. The uro-genital sinus forms the vulvar cavity or vestibulum of the vagina, which is so marked in the lower animals. The genital tubercle becomes the clitoris ; the genital furrow closes at a certain part to constitute the perinæum ; while the genital folds form the labia of the vulva. The mammæ—dependencies of the generative organs—appear after the first month of uterine life.

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