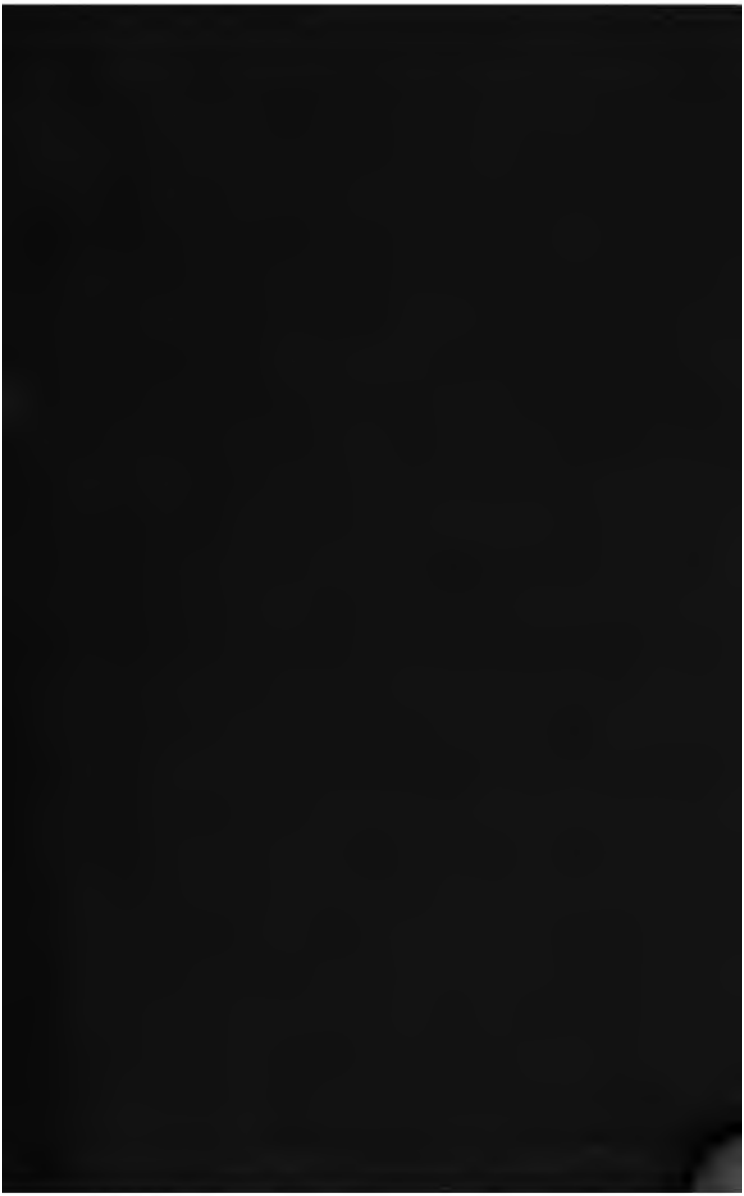
OUTLINES
OF
ZOOLOGY
AND
COMPARATIVE ANATOMY.

MONTGOMERY A. WARD,
M.B., M.Ch., Univ. Dub.



OUTLINES

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To

EDWARD LEDWICH, F.R.C.S.I.,

THIS SMALL VOLUME

IS DEDICATED,

BY HIS FORMER PUPIL, AND PRESENT COLLEAGUE,

THE AUTHOR.

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BY

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"Causa latet : vis est notissima.

Ovid, me[illegible] 287.

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PREFACE.

In the preparation of these pages, I lay claim to no originality, but have merely endeavoured to arrange and condense the leading features of Zoology and Comparative Anatomy for persons who may desire to obtain only a general knowledge of these subjects, but have not time to read the large standard works.

M. A. WARD.

1, Rathmines-road,
Dublin, *October, 1874.*

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INTRODUCTION.

On contemplating, even for a moment, the number of natural objects that almost daily come under our observation, we are struck with wonder and delight at their vastness and variety; and seeing that it has been stated by Ehrenberg that one single cubic line of water (less than a drop), is capable of containing 500,000,000 living Monads, and since the extent of space is unknown and indefinable—well may we exclaim that "it is impossible for the finite to comprehend the infinite." Every object in this world is either animate or inanimate, hence, two grand primary divisions of natural objects have been made, viz., the Organic or living world, and the Inorganic or dead.

The study of organic matter is termed Biology (*βίος*, life; and *λόγος*, an account of), and includes the departments of Zoology and Botany, while that of inorganic matter includes the departments of Geology, Mineralogy, Chemistry, and Physics. Three kingdoms in nature have been described, viz., the Animal, the Vegetable, and the Mineral. They are briefly defined by Linnæus in the following terse sentences:—The Animal, "Corpora organisita, et viva et sententia, sponteque se moventia;" the Vegetable, "Corpora

organisita et viva, non sententia;" the Mineral, "Corpora congesta, nec viva nec sententia."

The leading differences between organic and inorganic bodies are:—(1) Organic bodies generally present a definite shape, are more or less rounded, and have convex surfaces for their boundaries. Inorganic bodies, on the other hand, either have no definite shape, and are in this case termed *amorphous*, or if they do possess a definite form, they have angles and right lines for their boundaries, and are then called *crystalline*. (2) Organic bodies are termed *heterogeneous*, because in the great majority of cases they are composed of a number of separate and dissimilar parts. Inorganic bodies are termed *homogeneous* because (when pure and unmixed) they consist of an aggregation of similar particles. (3) The chemical composition of organic bodies is complex, and mainly consists of three or four elements, viz., Carbon, Hydrogen, Oxygen, and Nitrogen, united with each other in high combining proportions to form the component parts of the organism; they are liable to undergo spontaneous decomposition. The chemical composition of inorganic bodies is simple, and consists of few or numerous elements, either uncombined or, if united, forming low combining proportions; they are not liable to spontaneous decomposition. (4) Organic bodies grow by the reception and assimilation of nutritive food internally. Inorganic bodies increase in size by the addition of particles externally, technically termed "accretion of matter." (5) Organic bodies have the power of propagation. Inorganic bodies have not.

The possession of life forms the great distinguishing characteristic of the organic world: what then is life? Various definitions of life have been given by different authors, each and all of which have been more or less objected to. Thus it has been defined as "Organization in action" (Beclard); "The special activity of organized bodies" (Duges); "The constant uniformity of phenomena with diversity of external influences" (Treviranus). Although no exact definition of life has yet been framed, still it is a well-established fact that all the phenomena of vitality always manifest themselves through the medium of an albuminoid structure termed *Protoplasm*, more recently denominated by Dr. Beale *Bioplasm;* this substance constitutes what has been termed the "physical basis of life." By some it is asserted that this Protoplasm is the *cause* of vitality, while others state that it is only a *condition*. The external conditions necessary for the maintenance of life are, with few exceptions, water or moisture, air, temperature, and, usually, light. With regard to the first origin of life on this globe, I shall here quote Mr. Darwin's hypothesis. "I believe that animals have descended from, at most, only four or five progenitors, and plants from an equal or lesser number. Analogy would lead me one step further, namely, to the belief that all animals and plants have descended from some one prototype. But analogy may be a deceitful guide. Nevertheless, all living things have much in common, in their chemical composition, their germinal vesicles, their cellular structure, and their laws of growth and reproduction. We see this even in so trifling a cir-

cumstance as that the same poison often similarly affects plants and animals; or that the poison secreted by the gall-fly produces monstrous growths on the wild rose or oak tree Therefore I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form into which life was first breathed by the Creator."

The organic world is divided into two great kingdoms named the Animal and Vegetable; the study of the former is termed Zoology (ζῶα, animals, and λόγος, an account of); that of the latter Botany (βότανη, an herb). There are, however, a number of minute organisms which are sometimes classed among the plants, at other times among the animals, and as the transition between the two kingdoms is so gradual, and the border line by no means well defined, Dr. Ernst Hæckel proposed to establish an intermediate kingdom for the reception of all these organisms, which he designated the "Regnum Prostiticum." The following are the leading differences between animals and plants, arranged after Professor Galloway, and copied from Dr. Mapother's work on Physiology:—

A VEGETABLE IS AN APPARATUS of REDUCTION;	AN ANIMAL IS AN APPARATUS OF OXIDATION;
Is fixed;	Possesses the faculty of locomotion;
Evolves oxygen;	Absorbs oxygen;
Absorbs heat and electricity,	Evolves heat and electricity;
Decomposes carbonic acid,	Produces carbonic acid,
„ water,	„ water,

Decomposes ammonia;	Produces ammonia;
Produces organic substances;	Consumes organic substances;
Transforms inorganic matters into organic matters;	Transforms organic matters into inorganic matters;
Derives its elements from the earth and air.	Restores its elements to the earth and air.

There are, however, some exceptions to the differences laid down in the above table, as, for example, many animals in their mature condition are fixed; while some plants in their embryo state, and others in their adult, possess the power of locomotion conferred on them by cilia.

All animals are believed to be developed from a cell or cells. A perfect cell consists of the following parts:—a cell wall, termed the Periplast; granular protoplasmic contents, termed the Endoplast; a nucleus and usually nucleoli. The matrix or intercellular substance is called blastema; cells multiply in various ways—(1) By fission, where a cell separates into two distinct cells; (2) By gemmation, where a bud appears on the parent cell and ultimately becomes detached as an independent cell; (3) By Endogenous development, where the nucleus divides into two or more nuclei that form perfect cells within the parent cell before they are liberated; (4) By Exogenous development—where the nucleus divides into two or more nuclei that burst through the parent cell, and then become developed into perfect cells. Those, however, who advocate the "Molecular Theory" believe that molecules precede the formation of cells. Spontaneous or equivocal generation (Heterogeny) is the name given to the theory which has been advanced to

account for the appearance of microscopic organisms termed "bacteria," "vibriones," and "monads," which appear in the order named in organic infusions. This theory enunciates the possibity of the "origin of life" without pre-existing germs; on the other hand, the "Panspermists" who oppose this theory, account for the appearance of these organisms by the possibility of the existence of minute germs in the atmosphere, or in the fluid of these organic infusions which have hitherto escaped the observation of the most experienced Microscopists. The question is still "*sub judice*," and far from settled, though the results of the celebrated experiments of Dr. Bastian are in favour of the theory of heterogeny.

Three theories have been advanced to account for the varieties in the different beings that constitute the Animal Kingdom.

1. Theory of Special Creation.
2. „ of Progressive Development (Lamark).
3. „ of Natural Selection (Darwin).

1. The theory of Special Creation supposes that every new group of organisms that successively made their appearance in this globe were formed by a special act of the Creator.

2. "Proposes the idea of an innate tendency to the development of higher and more complex forms, in successive generations from monad to elephant or man, but allows the modifying influence of surrounding conditions"—(Ord).

3. The theory of Natural Selection supposes that, in

the struggle for life, the weakest perish; the strongest perpetuate themselves, and that the different surrounding external conditions are the agencies by means of which these effects are produced.

Classification.—I shall here merely give an abstract of the principal classifications that have been, from time to time, proposed.

I.

1. Animals possessed of blood (*i. e.*, red blood). This division corresponds to the vertebrata of modern writers.
2. Animals that were exsanguious or had a colourless fluid instead of blood. This division comprised the invertebrata of modern writers—(Aristotle).

II.

1. Animals having warm, red blood, and a heart consisting of four cavities.
   - *a.* Mammalia
   - *b.* Aves.
2. Animals having cold, red blood, and a heart having two cavities.
   - *a.* Reptilia.
   - *b.* Pisces.
3. Animals having cold, white sanies, and a heart containing a single cavity.
   - *a.* Insecta.
   - *b.* Vermes—(Linnæus).

III.

1. Animals whose hearts contain four cavities.
   - *a.* Mammalia.
   - *b.* Aves.
2. Animals whose hearts contain three cavities.
   - *a.* Reptilia.
   - *b.* Amphibia.
3. Animals whose hearts contain two cavities.
   - *a.* Pisces.
   - *b.* Most Mollusca.
4. Animals whose hearts contain only a single cavity.
   - *a.* Articulata.
5. Animals in which the functions, both of stomach and heart, are performed by the same organ, *e. g.*, Medusæ—(Hunter).

IV.

1. Vertebrata.
2. Mollusca.
3. Articulata.
4. Radiata vel Zoophyta—(Cuvier).

V.

1. Spini-cerebrata vel Vertebrata.
2. Cyclo-gangliata vel Mollusca.
3. Diplo-neura vel Articulata.
4. Cyclo-neura vel Radiata—(Grant).

VI.

1. Vertebrata.
2. Mollusca.
3. Molluscoida.
4. Annulosa.
5. Annuloida.
6. Cœlenterata.
7. Protozoa.

This last division of the Animal Kingdom into sub-kingdoms is the most modern and most generally adopted, and will be followed in the ensuing pages. Each sub-kingdom is further sub-divided into classes, orders, sub-orders (sometimes), genera, species, and varieties; *e. g.*, the Bull dog is a variety of the species canis familiaris, belongs to the genus canis; sub-order Digitigrade Carnivora; order Carnivora; class Mammalia; sub-kingdom Vertebrata.

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VERTEBRATA.

CHAPTER I.

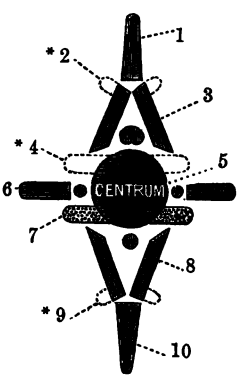
SUB-KINGDOM.—VERTEBRATA.

GENERAL DESCRIPTION.—Animals that possess a "noto-chord" or "chorda dorsalis" at some period of their existence, which is replaced before maturity by the vertebral column (in the Amphioxus the noto-chord is persistent throughout life):—skeleton, always internal: limbs, never more than two pair, sometimes absent: alimentary canal has a distinct inlet and outlet: portal and lacteal systems, always present: respiration is effected by distinct breathing organs, often assisted by the skin: heart contains two or more cavities (absent in Amphioxus): blood is red and corpusculated: nervous system is much better developed than in the highest of the Invertebrata: reproduction is always sexual, the sexes being in different individuals:

Most Vertebrates are		Oviparous.
Some	- -	Ovo-viviparous.
The higher	-	Viviparous.

This sub-kingdom has received its name in consequence of all its members possessing a vertebral column; a segment of this column is designated a vertebra, which Professor Owen defines as "one of those segments of the endo-skeleton which constitute the axis of the body and the protecting canals of the nervous and vascular trunks."

Unity of type pervades the whole sub-kingdom. All its members are fashioned after the same model—hence, a "typical" or "ideal" vertebra has been constructed, from which, however, there are many and various deviations; the nearest approach to it exists in the caudal vertebra of the crocodile, and in the skeleton of the fish. The accompanying diagram explains the "ideal vertebra."



"IDEAL VERTEBRA." (*Owen*).

1. Neural spine, sometimes bifid. 2. Zygapophyses, articular processes of neural arch. 3. Neurapophyses, forming sides of neural arch. 4. Diapophyses, upper transverse processes. 5. Centrum, or body. 6. Pleurapophyses, ribs. 7. Parapophyses, lower transverse processes. 8. Hæmapo-

physes, forming sides of hæmal arch. 9. Zygapophyses, articular processes of hæmal arch. 10. Hæmal spine, sometimes bifid. * Denotes the exogenous elements. All the others are the autogenous elements.

The accessory process situated behind the base of the transverse process of each lumbar vertebra, and the mammillary process situated on the posterior aspect of each superior articulating process of the same vertebræ in the human subject, have been respectively called the Anapophyses and Metapophyses.

Professor Owen has, moreover, constructed a "Typical" or "Archetype Skeleton."

The bones of the Cranium are now believed to be composed of four modified vertebræ, and are designated:

1. Nasal Vertebra or . . Rhinencephalic (*ῥίν*, nose; and *ἐγκέφαλος* brain).
2. Frontal „ . . Prosencephalic (*πρό*, in front; and *ἐγκέφαλος*).
3. Parietal „ . . Mesencephalic (*μέσος*, middle; and *ἐγκέφαλος*).
4. Occipital „ . . Epencephalic (*ἐπί*, upon; and *ἐγκέφαλος*).

The Vertebrata are divided by Professor Huxley into three divisions, and by Professor Owen into two, which comprise five classes (*sic.*):—

1. MAMMALIA (*mamma*, breast) 2. SAUROPSIDA (*σαύρα*, lizard; *ὄψις*, aspect) A. Aves.	Hæmatotherma (*αἷμα* blood; and *θερμόν*, warm) Warm-blooded Vertebrata.
3. ICTHYOPSIDA (*ἰχθύς*, fish; *ὄψις*, aspect) B. Reptilia. A. Amphibia. B. Pisces.	Hæmatocrya (*αἷμα*, blood; and *κρυός*, cold) Cold-blooded Vertebrata.
(*Huxley*).	(*Owen.*)

CHAPTER II.

Mammalia: General Characters.

Mammalia are vertebrate animals that possess mammary glands; all but two (the echidna and ornithorhyncus paradoxus) have teats; the young are always born in a helpless condition, and the skin is invariably covered, more or less, with hair.

Osteology.—The skull is united to the spinal column by means of two condyles; the lower jaw consists of two halves, each composed of a single piece and united in front, there is no quadrate bone; the vertebral column is, with few exceptions, divided into cervical, dorsal, lumbar, sacral and caudal regions. The cervical vertebræ are always seven in number;* the dorsal vertebræ generally thirteen, often more (in man there are only twelve); the lumbar vertebræ are usually six or seven, rarely less than four (in man only five); the sacral vertebræ are generally amalgamated to form a single bone, the sacrum (absent in whales); while the caudal vertebræ vary in number from four to forty-five. The thoracic cavity is enclosed by a series of ribs, which correspond in number to the dorsal vertebræ; the ribs, as a rule, are united to the sternum by cartilages, and not by bony pieces, as in birds; the front ribs, which reach the sternum, are termed "true," the hinder ones, which do not, are called "false." The sternum consists of several pieces placed one behind the other, which are usually amalgamated to form a single bone.

* For a long time it was believed that the sloth had nine, and the dugong six cervical vertebræ.

The normal number of limbs is four, hence Mammals have sometimes been incorrectly denominated Quadrupeds, for many of the Amphibia and Reptilia have also four legs. Whales and dolphins have only the anterior limbs. The anterior and posterior limbs respectively are connected with the body by the scapular and pelvic arches, and are variously modified in the different orders. Professor Haughton states that the best example of the Scapular arch exists in the bird, where the humerus works in a socket formed by four bones, viz., acromion, scapula, clavicle, coracoid; while the best example of the pelvic arch is seen in the alligator, consisting also of four bones, viz., ilium, ischium, marsupial, pubis.

Of the bones which typically form the scapular and pelvic arches, one or more may be absent, but it is important to remember that both the anterior and posterior limbs are formed after a simple and symmetrical plan, and are followed in succession by a series of bones. This is thus exemplified:

Scapular Arch (*typical*).	Pelvic Arch (*typical*).
Acromion, Scapula, Clavicle, Coracoid, followed by	Ilium, Ischium, Marsupial, Pubis, followed by (*Haughton.*)
1. Humerus.	Femur.
2. Radius and Ulna.	Tibia and Fibula.
3. Carpus.	Tarsus.
4. Metacarpus.	Metatarsus.
5. Phalanges.	Phalanges.

The bones enumerated above present many changes and modifications in the different classes of animals, the most remarkable of which will be mentioned. In Mammals the anterior limbs are always present, but the clavicle is frequently absent, and the acromion is often a mere process of the scapula, the coracoid, which is a distinct bone in birds and reptiles, is attached to the scapular arch. In the Monotremata alone of Mammals the coracoid remains separate.

The humerus and femur, as well as the bones of the fore-arm and leg, resemble each other; the bones of the wrist and ankle are subject to many modifications, while the fingers vary in number from one to five—thus, the horse has only one finger, which is believed to be the middle finger. The toes undergo similar variations, and do not always correspond in number with the fingers—*e. g.*, in the dog tribe (Canidæ) the fore feet have five toes, while the hind feet have only four; and in the Hyænidæ there are only four toes to each foot.

The bones of the different orders of Mammals do not differ much from those of man; in general, however, they are coarser, and in some, as in those of the head of the elephant, there are extensive air cells; while those of the Cetacea have no medullary canals, are coarse and fibrous externally, and spongy or cellular internally, the cells assuming a tubular arrangement. On examining a thin transverse section of a long bone belonging to man with a microscope of moderate power, there will be observed the openings of the vascular canals, called Haversian, surrounded with concentric laminæ, and "plasmatic canals," called "canaliculi" piercing the laminæ at right angles; the dilatations on these canals are termed "lacunæ" or "bone cells," and are arranged concentrically between the laminæ. It will be remarked further on, that the microscopic appearance of bone varies in the different classes of vertebrate animals.

Digestion.—The great majority of Mammals possess two sets of teeth, deciduous and permanent, hence they have been termed by Professor Owen, Diphyodonts (δίς, twice; φύω, I produce; ὀδούς, a tooth). Some have only one set, and are called by the same author Monophyodonts (μόνος, single; φύω, I produce; ὀδούς, a tooth); they are the Monotremata, Edentata, and Cetacea. In the scaly and great ant-eaters there are no teeth whatever, and they are present only in the

embryo of the whale-bone whales. They vary in number, from one in the narwhal* to 190 in the dolphin.

The Alimentary Canal consists of the following parts:—

a. Mouth.
b. Pharynx and Œsophagus.
c. Stomach.
d. Duodenum.
e. Small Intestines.
f. Large Intestines.
g. Rectum.

Salivary glands exist throughout the whole Mammalian class (except in the Cetacea), and follow closely the type presented in the human race; in the ant-eater they are greatly developed, and pour their secretion into a special reservoir, called a salivary bladder. There are three distinct forms of stomach seen in this class, viz., simple, compound, and complex. The simple stomach consists of a single cavity, and is met with in Bimana, Quadrumana, Carnivora, and in some of the Cheiroptera, Insectivora, Edentata, Cetacea, Marsupialia, and Monotremata. The compound stomach is a variety of the former, consisting of a single cavity partially divided by folds into two or more spaces; this form of stomach is seen in the Carnivorous Cetacea, Sloths, a few of the Rodents, and some others. The complex stomach is the most interesting of all, and is met with only among the Ruminants; it consists of four cavities, named as follows:—

a Paunch, Rumen, or Ingluvies.
b. Reticulum, or Honeycomb.
c. Omasum, Manyplies, or Psalterium.
d. Abomasum, or Rennet.

* The narwhal has a second tooth, but it is rudimentary.

The Liver is the largest gland in the bodies of most animals, and performs a double function—that of elaborating a secretion necessary for digestion, and eliminating an excretion of hydro-carbons from the blood. The Kidneys are situated in the lumbar region, and are principally engaged in eliminating from the blood nitrogen, in the form of urea.

Respiration.—All Mammals breathe by means of lungs, which are divided into lobes (except in the horse, elephant, and some of the mutilata); the inspired air is warmed to the temperature of the animal, and robbed of oxygen, while the expired air is charged with carbonic acid gas, watery vapour, and a minute quantity of organic matter. The peculiar respiration of the Cetacea will be described in another place.

Circulation.—The Heart consists of four chambers, and the blood contains non-nucleated red corpuscles, which are circular (except in the camel tribe, in which they are oval). The thoracic cavity is always separated from the abdominal by a muscular partition, termed the diaphragm or midriff.

Nervous System.—The encephalon in man has reached its maximum of development, and is much more complete and intricate in its formation than in the most sagacious of the other Mammals; as we descend through the different orders, we shall find it more simplified, the convolutions become less intricate, and gradually disappear, until we arrive at the Marsupialia and Monotremata, where we find the corpus callosum wanting. (See Owen's classification, postea.) In the same ratio the intellectual faculties decrease. In all Mammalia the cerebral hemispheres (*prosencephala*) overlap the olfactory lobes (*rhinencephala*) in front, and the optic lobes (*mesencephala*)—usually called corpora quadra-

gemina (for they are no longer bigeminal) behind. The pons Varolii is always present, and the cerebellum has lateral lobes in addition to a median one.

Senses.—The sense of taste is believed to exist in all Mammalia, except the Cetacea. The sense of touch is possessed by all Mammals, but in some it is more highly developed than in others. All Mammals have the sense of smell, except Cetacea; while those who possess it in a marked degree, such as the dog, have the turbinated bones extremely convoluted—hence termed the "labyrinth,"—for the purpose of increasing the sentient surface. The sense of hearing is universally present, and the formation of the middle and internal ear is very nearly similar throughout the entire class: the three ossicula always exist in the tympanum, while the cochlea, semicircular canals, and vestibule are invariably present; but the pinna and external auditory meatus are absent in the armadillos, moles, duck-moles, seals, and Cetacea. Those animals that have this sense very acute, like the bats, possess large pinnæ. The sense of sight exists throughout the entire class, except in the adult mole (in the young mole the eye is well developed). The coats and dioptric media of the eye are similar to those of man. All have lacrymal glands and eyelids, except the Cetacea, while in these the sclerotic coat is greatly thickened, as in fishes. There is situated at the inner canthus of the eye of Ruminants a gland, called the Harderian gland, for the purpose of assisting to lubricate the eyeball. Nearly all Mammals (with the exception of man, monkeys, the Edentata and Monotremata) have that peculiar membrane called tapetum lucidum in their eyes; it is this membrane that gives to a cat's eyes in a dark room the peculiar lustre so familiar to every one.

Various classifications of the Mammalia have been proposed. I have arranged in a tabulated form the three principal classifications now most generally adopted.

Sub-classes.	*Orders.*	*Sub-classes.*
A. Monodelphia (*μόνος* single; and *δελφύς*, womb)	1. Bimana	*A.* Archencephala (*ἄρχω*, I rulé; and *ἐγκέφαλος*, brain)
	2. Quadrumana 3. Carnivora 4. Proboscidea 5. Hyracoidea 6. Ungulata 7. Mutilata	*B.* Gyrencephala (*γυρόω*, I roll; and *ἐγκέφαλος*, brain)
	8. Rodentia 9. Insectivora 10. Cheiroptera 11. Edentata	*C.* Lissencephala (*λισσός* smooth; & *ἐγκέφαλος*, brain)
B. Didelphia (*δίς*, twice; and *δελφύς*, womb)	12. Marsupialia	*D.* Lyencephala (*λύω*, I loose; and *ἐγκέφαλος*, brain)
C. Ornithodelphia *ὄρνις*, a bird; and *δελφύς*, womb)	13. Monotremata	
(*De Blainville*).		(*Owen*).

Sub-classes.	*Orders.*
A. Mammalia possessing a discoidal deciduate placenta	1. Primates— *a.* Anthropida (Bimana). *b.* Simiadæ (Quadrumana). *c.* Lemuridæ (Quadrumana). 2. Insectivora. 3. Cheiroptera. 4. Rodentia.
B. Mammalia possessing a zonary deciduate placenta	5. Carnivora. 6. Proboscidea. 7. Hyracoidea.
C. Mammalia possessing a non-deciduate placenta	8. Ungulata. 9. Cetacea. 10. Sirenia. 11. Edentata.
D. Mammalia having no placenta	12. Marsupialia. 13. Monotremata.

(*Huxley*).

CHAPTER III.

MAMMALIA: ORDERS.

I. BIMANA contains only one genus and one species, homo. Man was formerly placed along with the Quadrumana in the order Primates by Linnæus and some other naturalists, but has now assigned to him a distinct order, in consequence of the many striking differences which exist between him and the gorilla, the most anthropoid of all Quadrumana: Professor Owen enumerates no less than thirty in the cranium alone. The following are the most important distinguishing characteristics of this order:—The possession of moral and reasoning faculties, the greater comparative development of the brain, the summit of the teeth form almost a perfect level, and are not separated from each other by any interval. The dental formula is—

$$\text{I. } \frac{2-2}{2-2} \quad \text{C. } \frac{1-1}{1-1} \quad \text{P.M. } \frac{2-2}{2-2} \quad \text{M. } \frac{3-3}{3-3} = 32.$$

The great toe is not opposable to the other digits, the foot is plantigrade, the arms are shorter than the legs, and are never used as instruments of locomotion; the body is erect.

The human family is, according to Blumenbach, composed of the following five races (Cuvier originally described the first three groups):—

1. *Caucasian* includes all Europeans (except Finns), the natives of Western Asia and Northern Africa. They possess the following characters—an orthognathous (*ὀρθή*, straight, and *γνάθος*, jaw) cranium, an elliptical or oval skull, well-formed forehead, small face, narrow medium-sized nose, thin lips, and prominent rounded chin; Camper's facial angle measures from 80° to 85°; their hair is soft and wavy, never crisp, and their skin is fair, or slightly brown.

2. *Mongolian* includes the natives of Central and Northern Asia, the Chinese, Japanese, Laplanders, and Esquimaux; they are for the most part nomadic and equestrian. They are characterized by having a pyramidal skull, low forehead, broad face, prominent cheek bones, olive skin, dark oblique eyes, and strong black hair; Camper's facial angle measures from 70° to 75°. Epicanthus often present. They are usually low in stature.

3. *Ethiopian* includes all the natives of Africa, and their descendants in the slave States. They have a thick prognathous (*πρό*, in front, and *γνάθος*) skull, and low retreating forehead, broad nose, thick protuberant lips, short crispy hair; their facial angle is somewhat smaller than that of the Mongolian. The calves of their legs are very high. Their skin is jet black, and unctuous.

4. *American* includes all the Aborigines except the Esquimaux. The external aspect of their skull and face bears a strong resemblance to the Mongolian, but is somewhat more elongated; their skin is often of a peculiar dark red colour, hence, they have been popularly called Red Indians.

5. *Malay* or *Oceanic* (Latham) includes the natives of Australia, New Zealand, Borneo, &c. They are known by their strong thick skull, narrow forehead, flattened nose, prominent cheeks, large eyes, thick lips, wide mouth, and prominent teeth. Their complexion is dark, and their hair is black, thick, and lank. Their limbs are long, weak, and badly developed.

Doctor Prichard has described three distinct types of skull occurring in the human family:—1st. The oval or elliptical that exists in the Caucasian family. 2nd. The Pyramidal; this variety is met with in the Nomadic races, and is seen in its most marked form among the Esquimaux. 3rd. The Prognathous; this form is observed among the African and Australian savages.

II. QUADRUMANA.—The great distinguishing characteristic of this order of Mammals is, the peculiar modification of their hind limbs, which serve the purpose of hands; in other words, the great toe is "opposable" to the other toes; the fore limbs may want a thumb, but when present, it is generally opposed to the other digits. The dental formula is the same as that of man, except in the monkeys of the New World, which have three præmolars at either side of each jaw instead of two; the summits of the teeth are never on the same level, and the canine are greatly developed. The members of this order are specially adapted for passing their existence among trees, and are all clothed with hair. They are subdivided, according to the position of their nostrils, into the following sub-orders:—

(*A.*) *Catarrhines* (κατά, down; and ῥίν).—In this sub-order, which is the highest of the Quadrumana, the nostrils are oblique, converging below, diverging above, they are truly quadrumanous, for the thumbs of all the limbs are "opposable" (except in Colobus—in this monkey the thumbs of the fore limbs are wanting); the tail is never prehensile, and is sometimes absent. They inhabit the Old World, and comprise the baboons, gibbons, chimpanzee, ourang-outang, gorilla, the semnipotheci and macaques of Asia.

(*B.*) *Platyrrhines* (πλατεῖα, broad; and ῥίν).—This sub-order includes those monkeys that have simple sub-terminal nostrils, placed far apart; the thumbs of the fore limbs are not opposable, or are wanting; they have three præmolar teeth on either side of each jaw (marmosets excepted, whose dental formula is similar to man's); the tail is prehensile. They inhabit the forests of South America, especially Brazil. The most remarkable members of this group are the howling monkeys; their hyoid bone and thyroid cartilage are greatly developed; the former constitutes a bony case which receives a large pouch communicating with the larynx: It is by the reverberation produced in this peculiar apparatus that these

monkeys make the tremendous sounds whence they derive their name. This class includes marmosets and spider monkeys.

(*C.*) *Strepsirhines* (στρέφω. I twist; and ῥίν).—The members of this group are characterized by having the nostrils twisted and placed at the end of the nose, and by the second digit of the hind limbs being furnished with a claw. They live in troops upon the trees, are nocturnal in habit, and pass the greater part of the day in sleep. They are affectionate, well tempered, and very active. Their habitat is Madagascar and its vicinity. In this sub-order are placed the lories, lemurs, and aye-ayes.

III. CARNIVORA.—This order contains the beasts of prey that live principally on animal food, some entirely, while a few of them eat fruit and other vegetable matters. These Mammals are distinguished by the possession of retractile or non-retractile claws, and by their dentition. They have both deciduous and permanent teeth; the number of incisors in each jaw is generally six; the canines are greatly developed; and the molars are mostly cutting teeth, furnished with sharp uneven edges; but one or more of the back teeth have tuberculated crowns. The dental formula varies greatly in the different members of this order; but, as the cats (Felidæ) constitute the most typical tribe, subjoined is their dental formula:—

$$\text{I. } \frac{3—3}{3—3} \quad \text{C. } \frac{1—1}{1—1} \quad \text{P.M. } \frac{3—3}{2—2} \quad \text{M. } \frac{1—1}{1—1} = 30$$

The clavicles are rudimentary or absent, their motions are rapid, and many are endowed with great muscular power, while the organs of sight and smell are well developed. They are subdivided, according to the character of their limbs, into three groups, viz.:—

a. *Digitigrade* (*digitus*, toe; and *gradus*, step).	b. *Plantigrade* (*planta*, the sole; and *gradus*).	c. *Pinnigrade* (*pinna*, a fin; and *gradus*).

(*A.*) *Digitigrade carnivora* walk on the toes, without bringing the heel to the ground, and are subdivided as follows:—

1. Those having tuberculated teeth behind each canine of lower jaw.
   - *a.* Those having one tubercular tooth behind each canine of lower jaw. — Vermin—*e.g.*, martin, otter, skunk, polecat, weasel, ferret, ermine.
   - *b.* Those having two tubercular teeth behind each canine of upper jaw, — *e.g.*, dogs, wolves, civets, foxes, and ichneumons.
2. Those having no tubercular teeth behind each canine of lower jaw, — *e.g.*, lions, tigers, panthers, leopards, cats (Felidæ), and hyænidæ.

The Felidæ, comprising the lion, tiger, panther, leopard, and cat, are the most typical of all the Carnivora. They walk lightly upon their toes; their head assumes a rounded form in consequence of the shortness of the jaws and the great size of the muscles that move the lower jaw; their legs are nearly equal in length, and the fore feet have each five toes, while the hind feet have only four; all the toes have strong retractile claws, which, when not in use, are kept in sheaths by means of elastic ligaments; the tongue is covered with horny elevations, that adapt it for the purpose of licking the flesh off the bones of their victims.

(*B.*) *Plantigrade Carnivora.*—The animals included in this division apply the sole of the foot to the ground in walking, and are less carnivorous in their habits than the *Digitigrades*. The bear, which may be taken as a type, has five fingers and five toes, and can stand on the hind legs more like a human being than the most anthropoid of apes; this peculiarity is due chiefly to the form of the thigh bone, which very much resembles a human femur, and has been often mistaken for one. The badgers and racoons also belong to this division.

(*C.*) *Pinnigrade Carnivora.*—The seals and walruses, forming this family, are specially adapted for an aquatic mode of life. The fore feet of the seal are not used in swimming; the hind feet are blended with the tail, forming a screw-shaped apparatus by means of which the animal is propelled through the water. The walruses are remarkable for having their canines enormously developed.

IV. Proboscidea.—This order of Mammals is characterized by having the nose prolonged into a trunk or proboscis, at the extremity of which the nostrils are placed, and by their peculiar dentition. The canine teeth are absent, but the incisors of the upper jaw are developed into enormous tusks which grow from permanent pulps; the molars are large, and few in number. The fingers are five in number, and so also are the toes; the feet are covered by a thick pad of integument; the clavicles are wanting; the testes are abdominal, and the mammæ pectoral. The elephant, the representative of this order, inhabits forests in the tropical regions of Asia and Africa, and lives to a great age. There are only two living species at the present day.

(*A.*) *The African Elephant* has a convex forehead, large flapping ears, four hoofs (nails) on the fore feet, three on the hind feet; it is of a darker colour and is much fiercer than the Indian elephant. The female possesses tusks as well as the male, and the plates of enamel on the molar teeth enclose lozenge-shaped spaces.

(*B.*) *The Indian Elephant* has a concave forehead, small ears, five hoofs (nails) on the fore feet, four on the hind feet; its colour is generally pale brown, and the transverse ridges of enamel on the molar teeth are narrow, parallel, and undulating.

V. Hyracoidea.—This order has been constituted by Professor Huxley for the reception of the single genus Hyrax, which comprises two or three small animals still classified by

Professor Owen among the *Perisso-dactyle Ungulates.* They are small gregarious animals living in holes in the rocks. One species occurs in South Africa, and is called the "badger;" another is found in Arabia and in Palestine, and is supposed to be the "coney" of Scripture. They are not unlike small Rodents, for the canines are absent, and the incisors of the upper jaw grow from permanent pulps; the molars are seven in number on either side of each jaw, and are very like those of the rhinoceros in form and structure.

VI. UNGULATA.—This order of herbivorous Mammals includes three entire old orders—Ruminantia, Solidungula, and Pachydermata; the elephant alone being removed from the Pachydermata, and placed in a separate order. All the members of this group are characterized by the possession of four limbs, which are useless for prehension, and only subserve the purpose of locomotion. The toes are encased by hoofs or "nails," and there are never more than four full-sized toes to each leg. The molars have broad crowns, for the purpose of grinding vegetable food. This order is sub-divided into two primary sections.

(*A*). *Perisso-dactyles* (περίσσος, odd; and δάκτυλος, a toe), or odd-toed ungulates, that have either one or three toes; the horns, if present, are never in pairs; and the dorso-lumbar vertebræ are more than nineteen. Perisso-dactyles are divided into—

1. Solidungulates.
2. Multungulates.

1. The Solidungulates comprise the horse, ass, zebra, quagga, and onagga; all possess a single toe encased in a broad hoof—hence the name (*solida*, solid, and *ungula*, a hoof). The bones of the fore leg of a horse are homologous to the bones of the human arm. They are here placed side by side for the purpose of comparison:—

Horse.	Man.
Scapula, homologous to	Scapula.
Humerus,	Humerus.
Radius and ulna, partially consolidated,	Radius and ulna separate.
Carpus, seven small bones (knee)	Carpus, eight small bones (wrist).
Metacarpus, one bone (cannon bone),	Metacarpal bone of middle finger.
Pastern,	Proximal phalanx of do.
Coronary,	Middle do. do.
Coffin,	Distal do. do.

In the same way the bones of the hind leg of a horse are homologous to the bones of the human leg, and what is termed the stifle-joint of a horse corresponds to the knee-joint of man (the stifle-bone being homologous to the patella), and the hock-joint, containing six bones, viz., astragalus, os calcis, cuboid, and three cuneiform, corresponds to our ankle-joint. The femur of the horse has three trochanters; the clavicle is absent, and there is no gall bladder.

2. Multungulates (*multæ*, many, and *ungulæ*, hoofs) comprise the rhinoceroses and tapirs. Rhinoceroses are very large, heavy animals; the feet have each three toes; they have one, or, it may be, two horns; when two are present they are placed in the median line, one behind the other, the posterior one being much the shorter; the horns possess no bony core. The tapirs have four fingers and three toes, and the nose is prolonged into a small, movable proboscis.

(*B.*) *Artiodactyles* (ἄρτιος, even; and δάκτυλος, a toe), or even-toed ungulates, are sub-divided into two groups—

1. Ruminantia.
2. Omnivora.

1. The Ruminants constitute a most important group of the ungulates, and are characterized by their peculiar dentition, by the structure of the stomach, and by that of the foot. The typical dental formula of a Ruminant is—

$$\text{I. } \frac{0—0}{3—3} \qquad \text{C. } \frac{0—0}{1—1} \qquad \text{M. } \frac{6—6}{6—6} = 32.$$

The incisors and canines of the lower jaw are similar in size and form. In consequence of the absence of these teeth in the upper jaw, the lower incisors are opposed to a hardened pad of gum. The camelidæ, however, form an exception, as they possess six incisors in their upper jaw. Ruminants have a complex stomach, which, as previously mentioned, consists of four cavities. In the adult animal the paunch is the largest of these cavities (in young Ruminants the abomasum is the largest), and serves the purpose of a temporary store-house for the food; it is lined with dense squamous epithelium, and secretes a watery fluid, which has little or no digestive function. In the camel tribe this paunch contains a number of pits, the openings into which are closed by muscular sphincters, and are capable of containing a large quantity of water—hence camels are able to travel far across desert plains in consequence of this beautiful provision of nature. The reticulum (*rete*, a net) is much smaller, and presents a honeycombed appearance. The small polygonal spaces into which it is divided form the food into small round balls, which are regurgitated into the animal's mouth, and are there re-masticated: this is what is termed rumination. The food, after rumination, passes again down the œsophagus, then along a groove situated on the upper margin of the reticulum into the manyplies. The manyplies has its mucous membrane arranged in parallel plates like the leaves of a book, hence its name. There are about eighty of these leaves in the ox, and forty in the sheep; from this cavity the food passes into the abomasum or rennet, which last is the true digestive stomach, and the homologue of the stomach of man.

The foot of Ruminants is always "cloven," and consists of a pair of symmetrical toes encased in hoofs; in a great

many there is a pair of supplementary toes placed on the back of the foot. Ruminants are sub-divided as follows:—

1. Ruminants without horns, *e.g.*, Camels, Alpacas. Llamas, and Musk-deer.
2. Ruminants with horns.
    a. Horns persistent.
        1. Covered by hairy skin, *e.g.*, Giraffe.
        2. Covered by horny case (cavicornia), *e.g.*, Ox, Sheep, Antelope, Goat.
    b. Horns deciduous (Antlers), *e.g.*, Stags (cervidæ).

Three distinct types of horns are found among the ungulata. 1st. Those that consist entirely of epidermic constituents, and are made up by the aggregation of horny fibres: this form is seen in the rhinoceros. 2nd. Those that consist of a central bony core, which is completely covered with a true horny case or hairy skin (vide antea). 3rd. Those that are formed of true bone, termed antlers, and are shed every year.

2. Omnivora, the last division of the ungulata, comprises the well-known pig, also the peccary and hippopotamus. They possess no third trochanter on the femur, and are all remarkable for the thickness of their integument.

VII. Mutilata.—These form a remarkable order of Mammals, and are all adapted for an aquatic life. The anterior limbs are changed into fins, while the posterior ones are wanting. The tail is horizontal and flat, and there are no external ears. Lacrymal glands are likewise absent. The Mutilata are divided into two groups:—

a. Cetacea (carnivorous).
b. Sirenia (herbivorous).

Cetacea are the largest of all living Mammals. They com-

prise the whale, dolphin, porpoise, and narwhal; they are fish-like in form and mode of life; they have one or two blow-holes on the top of the head, leading into the nostrils; their teats are inguinal, testes are abdominal, and they have no vesiculæ seminales. Their respiration is very peculiar, and the mechanism by which it is performed extremely interesting. It is thus accomplished: the top of the pharynx is guarded by a strong sphincter muscle, which is closed except when the whale expires, and thus prevents any communication between the cavity of the pharynx and the nostrils. The soft palate is greatly enlarged, so as to form a perfect septum between the mouth and the pharynx, thus enabling the whale to swim about under water with its mouth fully open, yet no water can enter its lungs. When the blood requires fresh oxygen, the animal rises towards the surface of the water, shuts its mouth, and commences to expire the impure air; the expired column of air is surrounded with a cylinder of water drawn up with it by friction—hence the mistake that these animals spout water. The Cetacea comprise three families, viz., whale-bone whales, sperm whales, and dolphins.

The whale-bone whales (balænidæ) have no teeth (the embryo has teeth, which never cut the gum), but possess instead transverse plates of whale-bone (baleen) attached to the hard palate; the inner edge of these plates is furnished with a close fringe of whale-bone fibres, by means of which the small molluscs on which this giant feeds are filtered from the water. They have a thick layer of fat (blubber) beneath the skin.

The sperm whales (catodontidæ, *κατά*, down; and *ὀδούς*, a tooth) are characterized by having a single blow-hole, and by having conical teeth in the lower jaw; there are also a few in the upper, but they never cut the gum. These animals are sought after for the *spermaceti* which is diffused through the blubber, and contained in special cavities in the

head, and for a peculiar substance called *ambergris*, found in masses in the intestines, and composed of a substance somewhat similar to cholesterine; this is used as a perfume.

Dolphins (delphinidæ).—This division comprises the dolphin, porpoise, and narwhal. They possess numerous conical teeth in both jaws, and the nostrils open by a single aperture at the top of the head. They inhabit most seas, and are very voracious. The narwhal is remarkable for the great development, in the male, of one of the incisors of the upper jaw.

Sirenia.—The Sirenia are also adapted for an aquatic mode of life, and comprise the Manatees and Dugongs, and are commonly called "sea cows." The snout is fleshy, and the nostrils are placed on its upper surface. The anterior limbs are turned into swimming paddles, and the hind limbs are entirely absent. There is a trace, however, of the pelvic arch; the intestinal canal is extremely long. The mammæ are pectoral, testes abdominal, and they have vesiculæ seminales. They are diphyodont, live on sea-weed, and keep near the shore.

VIII. Rodentia.—This constitutes the largest order of Mammals. It has been calculated that nearly one-third of the known Mammals are Rodents, and of these rats and mice form one half. They possess two incisors in the upper jaw (sometimes four), but never more than two in the lower; the canines are absent, and there is always a wide interval between the incisors and molars; of the latter there are rarely more than four on either side of each jaw; the feet have usually five toes, each toe being furnished with claws. The distinguishing peculiarity of the Rodents (*rodens*, gnawing) is seen in the structure of the incisor teeth, which grow from permanent pulps; they are large, curved, and covered in front by a layer of hard enamel. The result of this is that the softer dentine wears away more rapidly than the

enamel, hence the chiselled shape of the teeth. In some Rodents the collar bones are developed, in others they are absent; the testicles periodically descend from the abdomen into a temporary scrotum. To this order belong the hares, rabbits, beavers, squirrels, porcupines, guinea pigs, rats, mice, &c., &c.

IX. INSECTIVORA.—These animals, so termed from the fact of their subsisting almost entirely on insects, comprise the moles, shrews, and hedgehogs. They are characterized by their peculiar dentition; they have incisors, canines, and molars, the last-named having their summits furnished with numerous cusps; clavicles are always present; the toes are furnished with claws, and the majority of the order have five toes to each foot, and are plantigrade. The mole has extremely small eyes, and is well adapted for a subterranean life. The hedgehog is covered with spines, and the muscles of the skin are greatly developed, so that the animal can roll itself up into a ball when threatened with danger.

X. CHEIROPTERA (χείρ, the hand; and πτερόν, a wing), or bats, constitute a well-marked order of Mammals, and have the following distinguishing characteristics:—The fore limbs are much longer than the hind ones, and all the fingers, except the thumb, are greatly elongated, to support a membrane called the *patagium*, which is stretched between the fingers, and passes thence to the hind limbs (being attached to the sides of the body), and often includes the tail. This membrane is used in flight, and is analogous to the wing of a bird. When at rest, they suspend themselves by means of the thumb, which is furnished with a claw; from at least three of the other fingers claws are always absent; the clavicles are well developed, and the sternum is keeled for the attachment of the pectoral muscles; the feet are five-toed, and unguiculate. Animals of this order have the three

kinds of teeth, and the canines are well developed. They have no air cavities in the bones; the testes are retained in the abdomen, and only descend during the breeding season. They have large ears, small eyes, and are crepuscular or nocturnal in their habits. The most of them hybernate. They are divided into—

a. Insectivorous, e.g., all British Bats.
b. Frugivorous, e.g., Fox Bats.

XI. EDENTATA (Bruta) are the lowest order of placental Mammals, and comprise the ant-eaters, armadilloes, and sloths. They are characterized by the total absence of central incisors; the lateral incisors and canines are generally wanting, and sometimes the molars. The teeth, when present, are never covered with enamel, or replaced by a second set. The ribs exceed in number (twenty-three pair) that of any other Mammals; the toes are provided with strong, curved claws; the testes are abdominal. This order is divided into—

a. Herbivorous and *Arboreal, e.g.*, Sloths.
b. Carnivorous and *Terrestrial, e.g.*, Ant-eaters and Armadilloes.

XII. MARSUPIALIA (Didelphia).—This order has received its name in consequence of its female members possessing a "marsupium," or pouch, in which the young animal, which is always born in a very imperfect condition, is placed. This pouch is formed by a folding of the integument of the abdomen, and supported by the so-called marsupial bones; into the marsupium project long nipples from the mammary glands, through which the milk is forced by means of special muscles, as the young marsupial, when first born, is unable to suck. The oviducts open into vaginal tubes, which, in turn, open into a urino-genital canal, but there is no

"cloaca." The scrotum is placed in front of the penis in the male, and is supposed by Professor Owen to be the marsupium turned inside out. The order is divided into—

a. Herbivorous—Kangaroos, Kangaroo-Bears, Wombats, and Phalangers.

b. Carnivorous—Native Devil, Native Tiger, and Bandicoots.

XIII. MONOTREMATA (ornitho-delphia).—These animals form the connecting link between Mammals and birds, possessing some of the peculiar characteristics of each class. They possess a coracoid bone, which passes from the scapula to the sternum; the sternum is keeled like that of birds. A common cloaca receives the openings of the urino-genital organs and digestive canal; there are marsupial bones, but no marsupium; the mammary glands have no nipples; and the external ears are absent. There are only two known animals belonging to this order.

a. Duck Mole (ornithorhyncus paradoxus), not unlike a small otter. It is covered with a short brown fur, and has a broad flat tail. The jaws are covered with horn, so as to resemble the beak of a duck (ὄρνις, a bird; and ῥύγχος, a beak), and are furnished with small horny plates, which serve the purpose of teeth. The legs are each furnished with five toes, which are webbed.

b. Porcupine Ant-eater (echidna) is like a hedgehog, with a long snout, and is covered with hairs and spines. It is edentulous, and has a long flexible tongue. The feet have each five toes, which possess strong claws, but are never webbed.

CHAPTER IV.

Aves: General Characters.

The second great division of the Vertebrata consists of birds, and is thus defined by Professor Owen:—"Oviparous vertebrates, with warm blood, a double circulation, and a covering of feathers." The following are the more striking peculiarities observed in this division:—The skull articulates with the spine by a single condyle; the lower jaw articulates with the "os quadratum," which, in turn, articulates with the skull. There are no teeth, and the anterior limbs are changed into wings. The lungs communicate with air sacs scattered through the body, and many of the bones are pneumatic. The heart consists of four chambers, and the blood corpuscles are nucleated.

Osteology.—The skeleton of a bird possesses many points of interest, in consequence of its adaptation to the purposes of flight; it is compact and light; its compactness is owing to the great quantity of phosphate of lime which enters into its formation, and enables it to sustain the contraction of vigorous muscles; and the lightness is due to the existence of air cells, instead of marrow, which are indispensable for the purpose of flight. The cranial bones are anchylosed early, and the separate bones can only be demonstrated in the young bird; the lower jaw, however, remains distinct and movable. On examining a thin transverse section of one of the long bones of a bird under the microscope, it will be observed that the plasmatic canals exhibit oval dilatations. The cervical vertebræ vary in number, from nine in the sparrow to twenty-three in the swallow and swan; they

are very movable on each other, and this renders the neck so flexible that the head can be turned in every direction; they have, moreover, rudimentary costal appendages or ribs attached to their transverse processes. The bodies and spinous processes of the dorsal vertebræ are firmly consolidated together, and splints of bone proceeding from the transverse processes overlap each other, increasing the stability for the attachment of muscles. The lumbar and sacral vertebræ, and the bones constituting the pelvis, at an early period, are consolidated into one piece, so that the elementary constituents can only be made out in the very young bird; and the ossa pubis do not meet in front, except in the ostrich. The caudal vertebræ are movable, and terminated by the "plough-share" bone, which is composed of several vertebræ joined together, and supports the tail feathers, which act as a rudder, and the "uropygium" or oil gland, by whose secretion the feathers are lubricated. The ribs vary in number, from seven to eleven pair, each rib consisting of a dorsal and sternal portion connected by a joint; the dorsal portion is attached to the vertebræ by a double articulation, and, in most birds, gives off a process which passes over the succeeding rib; the sternal portion is connected to the sternum by means of a single articulation. The sternum is greatly developed, and is composed principally of the central *azygos element*, which, in birds of flight, is prolonged into a keel-like process (absent in the cursores) for the attachment of the three powerful pectoral muscles. The scapular arch is composed of a coracoid bone, which is the strongest and longest, extending from the scapula to the sternum—a slender scapula—a clavicle which joins with its fellow of the opposite side in front of the sternum, constituting the "os furculum," "funny bone," or "merry thought." This last bone is very variable; it is very strong in the raptores, and absent in the ground parrots of Australia. The humerus plays in a socket formed by the

scapula, coracoid, and clavicle; next come the radius and ulna, the latter being the stronger bone. The carpus consists of only two bones; the metacarpus is composed of two pieces joined at their extremities; at the proximal extremity on the outer side is a rudimentary digit, the "thumb," to which is attached a tuft of feathers called the "bastard wing." Succeeding the metacarpus there are two fingers, one of which has only one phalanx, while the other has two or three. In the penguin there are one or two small bones situated at the elbow-joint, which form a kind of patella, and are supposed to be portions of the olecranon process detached from the ulna. All these bones form the framework of the wing, and are homologous to the human arm, but not analogous. The pelvic arch is succeeded by a short and strong femur; this is followed by a tibia and rudimental fibula. The tarsus is amalgamated with the metatarsus, to form a single tarso-metatarsal bone, which is very large in the grallatores; to this bone is attached the foot, which, in most birds, consists of four toes, but these may vary from two to five; no wild bird has more than four, but some domesticated ones have five; and, no matter what may be the number of toes, the number of phalanges is constant—thus, the outermost toe has five, the next four, the third three, the second, when it is present, two, and the spur or innermost has one.

Digestion.—The digestive system of birds presents many extremely interesting structures, which shall be briefly described seriatim. The mouth, the only prehensile organ the bird possesses (except in the raptores and scansores, which use the foot as well), constitutes a beak encased in a dense horny sheath, and assumes various forms in the different genera. In many birds there is situated at the base of the bill a circle of skin called the "cere," which serves as an organ of touch. The tongue is supported by one or two

bony pieces proceeding from the os hyoides, and is covered by a horny sheath; it assists in deglutition, and has little or no gustatory function; and in the parrot tribe, is used as a thumb opposed to the upper mandible; in the woodpeckers it is turned into a regular harpoon, and, in the honey-eating birds, has, at its extremity, a tuft of horny filaments, not unlike a camel's hair brush. Salivary glands are always present, are simple in structure, and small, except in the woodpecker; in this bird they attain a large size. The pharynx is simple, and leads into an œsophagus or gullet, which, in the flesh-eating and grain-eating birds, is dilated into a "crop" or "ingluvies" that acts as a store-house; the gullet again contracts to its former size, and then dilates a second time, to form the "proventriculus" or "bulbus glandulosus:" this is the true digestive stomach that secretes gastric juice, and terminates in the gizzard. The walls of the gizzard are very strong and muscular, especially in the grain-eating birds, who triturate their food therein with the assistance of small pebbles, instinctively swallowed for this object, which act as teeth. In birds of prey that live on easily digested food, the walls of the gizzard are thin. The intestinal canal extends from the gizzard to the cloaca, and at its commencement receives the secretions of the liver and pancreas; it is comparatively short, though longer in the grain-eaters than in the flesh-eaters, and two blind tubes mark the distinction between the large and small intestines. The cloaca is the common receptacle, in birds and reptiles, for the termination of the intestine, and for the ducts of the urinary and generative organs. The liver of birds is large, and consists of two principal lobes; it receives its venous blood, from which the bile is elaborated, from the renal and sacral veins, in addition to the gastric, splenic, and intestinal, which form the vena porta of Mammals. Two distinct sets of ducts convey the bile from this organ; the first conduct the bile to the gall bladder, from which another duct pro-

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ceeds to the duodenum; the second go directly to the intestine, consequently the "ductus communis choledochus" of Mammals is absent. The gall bladder is absent in some birds, as the ostrich, pigeon, parrot, and toucan. The pancreas, from which emanate generally two or three pancreatic ducts, is large and well developed; the spleen is small; the kidneys are long, and situated in recesses in the lumbar region; they are composed of cortical substance only. There is no urinary bladder, and the urine is almost solid, forming a pulpy mass, which chiefly consists of urate of ammonia and uric acid. There are two thoracic ducts, which pour their contents into the right and left subclavian veins. Lacteals and lymphatics are well developed.

Respiration is more perfectly accomplished in birds than in any other division of the vertebrata. The lungs, two in number, are large, spongy, bright red in colour, and immovably confined to the back part of the chest, so that expiration is effected by means of the sternum being drawn towards the vertebral column by muscular action, while inspiration is due to the sternum regaining its original position through the resiliency of its connexions. The majority of birds possess a double larynx, one situated at the top, the other at the termination of the trachea just before it bifurcates into the two bronchial tubes; this latter, when it exists, is the true seat of vocalization. The trachea, in many birds, especially among the grallatores, dilates into wide chambers of various forms, the object of which is unknown, and in the wild swan becomes lengthened and contorted in a remarkable manner before it terminates. The bronchial tubes branch dichotomously through the lungs, and conduct the air by two large apertures into the common thoracico-abdominal cavity (for the diaphragm is absent except in the apteryx and a few others), which is divided into a number of "air receptacles"

by means of fibrous septa; from these the air gains admission into a greater or less number of bones—thus, in birds of flight, the upper extremities alone are pneumatic; in the cursorial, the lower ones only. In the pelican and ganet, all the bones, except the phalanges of the toes, are pneumatic, and in the horn-bill even these are so, while in the penguin, which does not fly, none of the bones are pneumatic. In young birds the bones are filled with marrow instead of air.

Circulation.—In birds, as in Mammals, there is both a pulmonic and systemic circulation. The heart consists of four distinct chambers, and is placed in the median line. The principal difference between the heart of birds and Mammals is found in the right ventricle, where a single thick triangular valve represents the tricuspid valve of Mammals; two superior venæ cavæ and one inferior open into the right auricle (this is likewise the case in proboscidea and rodentia); the aorta arches over the root of the right lung. The blood and general temperature of the body is much warmer in birds than in Mammals.

Nervous System.—The nervous system consists of both the cerebro-spinal and sympathetic systems, and presents a general resemblance to that of Mammals, but is not so highly developed; a marked superiority is, however, observed when compared with that of reptiles. The cerebrum possesses no convolutions; the corpus callosum and fornix are wanting, and in their stead there is a simple commissure. The cerebellum consists only of a central portion, and there is no pons varolii. A narrow canal runs through the centre of the spinal cord, which dilates inferiorly into a cavity filled with a watery fluid; the cord becomes thickened where the plexuses are given off that supply the wings and legs. The sympathetic system is well developed, and is arranged in the same way as in man. The situation of the cervical ganglia

is remarkable, as they are lodged in a long canal formed by the transverse process of the cervical vertebræ, which also contains the vertebral artery.

SENSES:—

Taste.—The sense of taste is very imperfect, as the skin of the tongue is covered with a thick horny sheath, and there is a total absence of gustatory papillæ.

Touch.—This sense is also extremely imperfect, as the body is clothed with feathers, and the limbs are covered with plumes or horny scales, whereby the bird is rendered ill adapted for receiving sensory impressions from external objects; it is, however, chiefly located in the bill, tongue, and soft corium of some birds' feet.

Smell.—This sense is, comparatively, better developed than the others. There are two nasal cavities, separated by a perfect septum narium, and in each are three turbinated bones, the middle being the largest. The olfactory nerves enter the nose by a single aperture (except in the apteryx), as there is no cribriform plate in the ethmoid bone. The nostrils are simply holes that perforate some part of the horny sheath which covers the upper mandible; they are absent in the pelicans.

Hearing.—The pinna or auricle is absent (in the bustard a circle of feathers around the ear acts as a pinna). There is a short external auditory meatus, while one bone, called the *columella*, usurps the place of the small bones situated in the middle ear of man. The vestibule and semicircular canals are well developed, and the cochlea is bent, but does not form a spiral tube—nevertheless, it is divided by a lamina spiralis into a scala vestibuli and scala tympani.

Sight.—The eye of a bird, when contrasted, on the one hand, with that of Mammals, and, on the other, with that of fishes, presents many striking points of difference, and affords an example of an optical instrument of exquisite

construction, designed to suit the condition in which its possessor is placed. The first thing that strikes the observer is the peculiar shape of the eye, which is not spherical as in man, nor flattened as in fishes, but becomes elongated from before backwards, thus rendering the cornea extremely prominent, the effect being to allow more room for a larger quantity of aqueous fluid, and to permit the lens to be removed farther from the retina, and thereby produce a greater convergence of the rays of light, in consequence of which the animal can discern objects placed near it. In addition to the ordinary tunics and humours of the human eye, a bird possesses, first, from thirteen to twenty imbricated bony plates, imbedded in the anterior portion of the sclerotic—these plates preserve the conical shape of the eye; second—an erectile structure termed the "*marsupium*" or "*pecten*," situated in the posterior part of the vitreous humour, that regulates the focal distance between the lens and retina; thirdly—muscular fibres arranged round the circumference of the cornea, and attached to its internal layer for the purpose of drawing back the cornea: these were discovered by Sir Philip Crampton. The iris is remarkable for the activity and extent of its movements, which, in many birds, appear to be voluntary. The muscles in the orbital cavity of a bird are the same as in man, with the addition of a special depressor of the lower lid, and the pyramidalis and quadratus muscles. The superior oblique, however, arises from the anterior part of the orbit, and does not pass through a pully. Eye-lashes are nearly always absent, but, in addition to the upper and lower lids, birds have a third or *membrana nictitans*, which is swept across the eye by means of the *pyramidalis* and *quadratus* muscles, in the following manner, viz.:—The quadratus arises from the upper part of the globe, descends towards the optic nerve, and terminates in a pully; the pyramidalis arises from the inner aspect of the eye-ball, forms a tendon that passes

through the pully of the quadratus, and winds around the optic nerve, to be inserted into the lower corner of the membrana nictitans. When both these muscles contract, the membrana nictitans is drawn across the eye; this membrane is transparent, for birds look through it, as, for example, when the eagle looks at the sun. The lachrymal gland is situated in the same place as in man, but there is found, in addition to what man possesses, a gland called the "*harderian gland*," placed behind the conjunctiva at the nasal angle of the eyelids, and supposed to be the representative of the meibomian follicles.

FEATHERS.—All birds are clothed with an epidermic covering called feathers, which agree in their mode of development with the hairs of Mammals, but are more complicated in their structure. A typical feather consists of the following parts—the "quill" or "barrel," the central axis or shaft, the webs or vane. The quill or barrel is a horny cylinder, narrowed at the extremity, which is inserted into the skin on its own dermal papilla, and contains some shrivelled skin called "pith," which was originally prolonged into the quill as a vascular membrane from the formative papilla. The shaft is a continuation of the quill, and tapers gradually towards the extremity of the feather; there is a longitudinal groove on its under surface, and it is convex on its upper; it is composed of a white spongy substance, like the pith of a plant, covered with a horny sheath. The webs are composed of numerous barbs that arise from the shaft, and are arranged in a single series on each side, while the barbs are connected to each other by means of minute filaments named "barbules." At the point where the shaft joins the quill, there is a small feather called the "plumule." Some of the barbs in the lower part of the feather are not connected by barbules, and constitute the down. In the ostrich and emeu all the barbs are disconnected, hence the

soft character of the plumage of these birds. The two principal modifications of feathers are the quills and plumes, the former are confined to the wings and tails, the latter form the general covering of the body. The largest quill feathers arise from the bones of the hand, and are called "primaries;" the next arise from the distal end of the fore-arm, and are termed "secondaries;" while the last arise from the proximal end of the fore-arm, and are called "tertiaries." The feathers covering the humerus and scapula are called "scapulars," while the rudimentary thumb carries the "alula" or bastard wing. The bases of the quill feathers are covered with feathers called the "wing coverts," which are divided into primary and secondary, while the feathers of the tail are furnished with numerous muscles, and their bases are covered above and below by feathers called the "tail coverts." Feathers are developed from dermal papillæ situated in a sac of the true skin, which is at first closed, but subsequently envelopes the base of the full-grown feather. Once or twice a year the whole plumage of the bird is renewed, and this is termed moulting. Besides the feathers above described, the skin of many birds, especially the aquatic species, is covered with a thick coating of down. This down is composed of a multitude of small feathers of a peculiar construction; each down feather consists of a small soft tube imbedded in the skin, from the interior of which springs a small tuft of filaments without any shaft; these filaments are very slender, and have on either side a series of still more minute filaments. An unctuous secretion, provided for the purpose of lubricating the feathers, is secreted by the "uropygium" or coccygeal oil gland, which is situated at the back of the coccyx.

Reproductive Organs.—The male generative organs of birds consist of two testes, situated in the lumbar region in front of the kidneys, from each of which a vas deferens

arises, and terminates in the "cloaca." In the majority of birds there is no penis, but in lieu thereof there are two small papillæ at the termination of the vasa deferentia, so that copulation must take place by simple juxta-position of the sexual orifices. In the natatores and cursores, however, there is a rudimentary penis. The female organs of generation present some remarkable points of interest, as they are not symmetrically developed on the two sides of the body, the right oviduct, and most frequently the corresponding ovary, remaining permanently atrophied. The oviduct on the left side commences with a wide, funnel-shaped aperture, and then becomes convoluted like the intestine, and ultimately terminates in the cloaca; its lining membrane varies with the different functions that the successive portions of the tube are called upon to perform. Thus the mature ovulum, on escaping from the ovisac of the ovary, enters the oviduct; as it is passing through the first portion of the oviduct termed the "*infundibulum*," it is covered by the albumen and chalazæ which this portion of the tube secretes the succeeding portion, called the "*isthmus*," secretes the membrana "putaminis;" and the last, denominated the "*uterus*," furnishes the shell, after which the egg is expelled through the cloaca. It is there developed by the process of incubation, and the young bird, when ready for an independent existence, perforates the shell, often by means of a temporary calcareous nodule developed on the tip of the bill. Before proceeding to describe the regular classification of birds, it should be mentioned that those which remain permanently in the place where they were hatched are called "permanent birds" (aves manentes); those that wander from place to place without following any definite rule are termed "wandering birds" (aves erraticæ); while those that undertake long journeys at fixed periods are denominated "migratory birds" (aves migratoriæ). Birds are divided into the following eight orders:—

1. Natatores—swimmers.	Carinatæ (*carina*, a keel).
2. Grallatores—stilt-walkers.	
3. Raptores—snatchers.	
4. Rasores—scratchers.	
5. Scansores—climbers.	
6. Insessores—sitters.	
7. Cursores—runners	Ratitæ (*ratis*, a raft).
8. Saururæ (σαῦρος, a lizard)—extinct	Saururæ. (*Huxley*).

I. NATATORES, or swimming birds, have a boat-shaped body, with a long neck; the legs are short, and placed behind the centre of gravity of the body; the toes are always more or less webbed, and are closely covered with feathers and down; the oil gland "uropygium" is greatly developed. They are mostly polygamous, and the young can feed themselves when they are liberated from the shell. They are divided into the following families:—

a. Brevipennes—Penguins, Divers, Puffins, &c.
b. Lamellirostres—Ducks, Geese, Swans.
c. Toti-palmatæ—Pelicans, Cormorants, Ganets.
d. Longipennes—Petrels, Seagulls, Albatroses.

II. GRALLATORES, or wading birds, have long legs, destitute of feathers from the tibia downwards; the toes are long, straight, and never webbed; the wings are long, and the power of flight great; the tail is small, and the legs are stretched out behind during flight; the body is usually slender, and the neck and beak long. They are divided into the following families:—

a. Macrodactyles—Rails, Water-hens, Coots.
b. Cultirostres—Cranes, Storks, Herons, Ibices.
c. Longirostres—Curlew, Snipe, Woodcock, Red Shanks.
d. Pressirostres—Plovers, Bustards, Oyster-catchers.

III. RAPTORES, or birds of prey, have a powerful muscular body, short and strong legs, with three toes in front and one behind, furnished with long curved claws or talons; the bill is hooked, the upper mandible being the longest; the wing is generally pointed and large. They are monogamous, the female being larger than the male. They are divided into—

a. Nocturnal Raptores—Owls (strigidæ).
b. Diurnal Raptores—Falcons, Eagles, Hawks, Vultures.

IV. RASORES, or scratchers, also called gallinaceous birds, have strong legs, generally covered with feathers to the lower part of the tibia. There are four toes, three in front and one behind; the latter, called the "hallux," is placed higher up than the others; all the toes have strong blunt claws, suitable for scratching. The beak has the upper mandible convex, and the nostrils pierce a membranous space at its base, and are covered by a cartilaginous scale. They have a large crop, and a very powerful gizzard. The sternum is truncated in front, and the os furculum is connected to it by ligament only. The wings in the majority of these birds are weak, and their flight is consequently feeble. They are divided into—

a. Gallinacei or *Clamatores*—Fowl, Turkey, Partridge, Grouse, &c. (the males usually have a spur called calcar).
b. Columbacei or *Gemitores*—Doves, Pigeons, &c.

V. SCANSORES, or climbing birds, are at once distinguished by their feet being provided with four toes, two of which are turned forwards, and two (the hallux and outer toe) backwards; in a few the hallux is absent. They are all monogamous, and comprise the cuckoos, woodpeckers, parrots, and toucans.

VI. INSESSORES, also called perchers, passeres, and songsters, form the most numerous order of birds. They are monogamous, and build their nests on trees; the females are smaller and less brilliantly coloured than the males; the young leave the egg in a blind and naked condition. The brain in this order attains its greatest comparative size, and the organ of voice its greatest complexity. They have short, slender feet, with four toes, three in front and one behind, each furnished with a claw. The following is the mechanism by means of which these birds, in common with all others that roost, are enabled to maintain their equilibrium when at rest:—"In the hind limb of most birds there is a singular extensor muscle, which arises from the pubis, ends in a tendon which passes to the outer side of the knee-joint, and terminates in the leg by uniting with the flexor digitorum perforatus. The result of this arrangement is that the toes are flexed whenever the leg is bent upon the thigh, and consequently the roosting bird is held fast upon his perch by the weight of his own body"—(Huxley). They are divided, in accordance with the form of the beak, into—

a. Conirostres, *e.g.*, Sparrow, Bullfinch, Crow, Starling, Larks, Finches, &c.

b. Dentirostres, *e.g.*, Thrushes, Blackbirds, Fly-catchers, Tits, Warblers, Shrikes.

c. Tennuirostres, *e.g.*, Creepers, Honey-eaters, Humming-birds, Sun-birds, &c.

d. Fissi-rostres, *e.g.*, Swallow, Martin, Swift, Goat-sucker.

VII. CURSORES, or runners, are characterized by the rudimentary condition of their wings, the great length and strength of their legs, the absence of a keel on the sternum, the junction of the two pubic bones to form a symphisis, the presence of marrow in many of their bones, and the

absence of barbules. This order contains the African ostrich, with two toes; the American ostrich (rhea), the emeu, and the cassowary, with three toes each, also the apteryx.

VIII. SAURURÆ.—This order contains the single extinct bird called the archæopteryx macrura, which differed from all known birds in having had two free claws to the wing, and a long tail composed of separate vertebræ, without any ploughshare bones.

CHAPTER V.

Reptilia: General Characters and Orders.

Reptilia (*repo*, I creep) have received this designation from their creeping method of locomotion, and are typically represented by serpents and snakes who actually creep. They constitute a large and important class of the vertebrata, and are extremely interesting to man, in consequence of their containing a number of venomous and formidable animals.

Osteology.—The skull articulates with the vertebral column by means of a single condyle; each side of the lower jaw is composed of several pieces, and articulates with the skull by the intervention of the os quadratum. The number of vertebræ comprising the spinal column varies very much in the different orders. In the majority of existing reptiles, each vertebra is procœlous (πρό, in front; and κοίλος, hollow), *i.e.*, concave in front, and convex behind, so that there is a perfect ball and socket-joint formed between every two contiguous vertebræ. The limbs may be absent, as in snakes, or rudimentary, as in some lizards, but generally both pair are present. Ribs are always present, but they vary greatly in form. A thin section of a reptilian bone, under the microscope, exhibits elongated oval dilatations on the plasmatic canals, best defined in the serpents, *e.g.*, python.

DIGESTION.—Teeth are usually present, but are not placed in alveoli, except in the crocodilia; in the tortoise and turtle there are no teeth. The alimentary canal is contained in a common thoracico-abdominal cavity, and its different portions have received the same names as those of other vertebrata; it always terminates in a common "cloaca," which receives the products of the urinary and generative organs. All the members of this class possess a lacteal and lymphatic system, salivary glands (rudimental), liver, spleen, pancreas, and kidneys, all of which perform their wonted functions.

RESPIRATION.—All reptiles possess lungs, but never branchiæ at any period of their existence; the lungs are less cellular than in birds and Mammals, and occupy the common thoracico-abdominal cavity, for the diaphragm is absent, though traces of it exist in crocodiles.

CIRCULATION.—The heart consists of two auricles, and one ventricle divided into two parts by an incomplete septum; the septum is, however, complete in crocodilès, but even in these there is a communication between the aorta and pulmonary artery, called the "foramen of Panizza," immediately after these vessels spring from the heart, which permits the admixture of the arterial and venous blood. The following is the course taken by the blood, which is cold, and has its red corpuscles nucleated:—All the venous blood of the body is poured into the right auricle by the caval veins, and thence passes into the ventricle; all the pure arterial blood coming from the lungs enters the left auricle, and is then driven into the ventricle—thus, the ventricle contains a mixture of arterial and venous blood, and when it contracts, it propels this mixed blood through the body by means of the aorta, and to the lungs by means

of the pulmonary artery. In consequence of this peculiarity in their circulation, reptiles have a low temperature and slow circulation.

NERVOUS SYSTEM.—The brain of reptiles is very like that of fishes, but the cerebral hemispheres are larger, and contain a cavity. The spinal cord is large, as compared with the brain, and a canal runs through its entire length, as in birds.

SENSES.—The senses of touch, taste, and smell are very imperfect. The sense of sight is good, the coats and dioptric media of the eye being similar to those of man. A lachrymal apparatus is always present, but in the ophidia there are no eyelids. All reptiles possess—an internal ear, consisting of a vestibule, three semi-circular canals, and a rudimentary cochlea; a middle ear, containing three ossicula (ophidia have only one ossicle, called the columella), a Eustachian tube, and membrana tympani.

REPRODUCTION.—The males possess testes that are abdominal in position, and vasa deferentia which terminate in a penis. Lizards and serpents have a double extra-cloacal penis; in tortoises and turtles this organ is single, and intra-cloacal. The female generative system requires no special notice. Most reptiles are oviparous, but some are ovo-viviparous. The remaining peculiarities will be mentioned in describing the different orders. Reptilia are divided into—

Saurian (*σαύρος*, a lizard)
1. Crocodilia (*κροκόδειλος*, a crocodille)
2. Lacertilia (*lacerta*, a lizard)
3. Ophidia (*ὄφις*, a snake; and *εἶδος*, form)
4. Chelonia (*χελώνη*, a tortoise)

} Recent.

5. Icthyopterygia (*ἰχθύς*, a fish; and *πτερύγιον*, a little wing)
6. Sauropterygia (*σαύρος*, and *πτερύγιον*)
7. Anomodontia (*ἄνομος*, irregular; and *ὀδούς*, a tooth)
8. Pterosauria (*πτερόν*, a wing; and *σαύρος*)
9. Deinosauria (*δεινός*, frightful; and *σαύρος*)

} Extinct.

I. Crocodilia.—All the members of this order are carnivorous; they inhabit fresh water, and are found in the large rivers of both the Old and New World. They possess the following characteristic peculiarities:—The bones of the skull are firmly united together, but the sutures uniting them never become obliterated, so that the individual bones can easily be demonstrated; the two rami of the lower jaw are united in front by a suture. There is a single row of teeth implanted in distinct sockets; the base of each tooth is hollow in consequence of the absorption produced by the succeeding tooth, which is half formed, and occupies this cavity, at the base of which may be found the germ of another tooth—thus, nature has provided the means for the successive replacement, during the life of the animal, of each tooth as soon as it is worn out. The vertebral column is always completely ossified, and is divided into cervical, dorsal, lumbar, sacral, and caudal regions; the cervical vertebræ are generally nine in number, the dorsal eleven or twelve, the lumbar three or four, the sacral two, and caudal never less than thirty-five; the præsacral vertebræ are said to be always twenty-four. All the vertebræ in existing crocodilia (except the atlas, axis, two sacrals, and first caudal) are procœlous. The cervical vertebræ have small ribs attached to them, and for this reason these animals have much difficulty in turning their necks. The

caudal vertebræ have both a hæmal and a neural arch. The thorax is composed of a sternum and two sets of ribs, viz., dorsal and sternal, connected together by cartilage. The anterior portion of the sternum is osseous, but posteriorly it becomes cartilaginous, and is prolonged as far as the pubis, on each side giving attachment to eight abdominal ribs, supposed to be represented in man by the tendinous intersection of the rectus abdominis muscle; there are no clavicles. All four limbs are present, the anterior being provided with five toes, the posterior with four. The mouth is large, and, in addition to the conical teeth already described, contains a large, fleshy, movable tongue. The orifice leading from the mouth into the pharynx and larynx can be closed by means of a strong valvular apparatus, formed by a prolongation of the soft palate, and a muscular membranous expansion arising to meet this from the hyoid bone; and as the nostrils open at the extremity of the mouth by a single aperture, the crocodile is able, without any inconvenience, to hold his prey under water, the nostrils opening into the pharynx behind this valvular septum. The œsophagus is short, and leads into a strong gizzard-like stomach, which often contains stones to assist in the proper trituration of food.* The pyloric opening, guarded by a valve, is situated near the cardiac extremity, and leads into a short intestine, which terminates in a common cloaca, the aperture of which is longitudinal. The heart consists of four distinct chambers, as the ventricular septum is complete, but nevertheless the arterial and venous blood always communicate through the "foramen of Panizza," which is situated between the pulmonary artery and aorta, immediately after their origin. The eyes possess the same tunics and humours as in man, and are guarded by three eyelids.

* Professor Haughton found several flint stones in an alligator which he dissected.

The ear consists of a vestibule, three semi-circular canals, a rudimentary cochlea; a middle ear, containing three ossicles, a membrana tympani, and a movable ear-lid. The body is covered by a layer of horny epidermic scales, resting on a dermal skeleton of bony plates or scutes, which may be present only on the dorsal aspect, or may exist on the ventral as well. This order is divided by Professor Owen into the following sub-orders:—

a. Procælia (*πρό*, in front; and *κοίλος*, hollow).—Recent.
b. Amphicælia (*ἀμφί*, on both sides; and *κοίλος*) } Extinct.
c. Opisthocælia (*ὄπισθε*, behind; and *κοίλος*) }

Procælia contain all the existing members of the crocodilia, and are divided into—

1. Gavial (India), having a long snout, and numerous even teeth.

2. Crocodile (Nile), having a long obtuse snout, and the fourth tooth in the upper jaw large and visible.

3. Crocodile vel Alligator (America), having a broad snout, and the fourth tooth in lower jaw large and concealed.

II. Lacertilia.—All the members of this order are distinguished by the following characters:—The majority of them have four limbs, a few have only two, while some have none; all, however, possess a scapular arch; movable eyelids are generally present—in the snake-like forms always so—thus at once distinguishing this order from the ophidia. The dorsal vertebræ are generally procælous, rarely amphicælous; there is a single transverse process, and the heads of the ribs are simple; there is no sacrum. The teeth are never implanted in distinct sockets. The heart consists of two auricles, and a single ventricle, which is incompletely divided by a septum. The aperture of the cloaca is trans-

verse. An exoskeleton, composed of horny epidermic scales, is almost always present. This order includes the Lizards, Chamæleons, Iguanas, Geckoes, and Slow-worms.

1. *Lizards* (lacertidæ).—This group comprises the typical lizards. They have two pair of well-developed limbs, each furnished with five toes of unequal length. The body is covered with scales, which are developed into shields or "scuta" over the abdomen and on the head; the tail is rounded; the tongue is slender, bifid, and protrusible. This family includes the sand-lizard (lacerta agilis), the viviparous lizard (zootoca vivipara), and the green lizard (lacerta viridis). Closely allied to the true lizards are the monitors (varanidæ), in which the abdomen and head are covered with scales instead of "scuta"—these are the largest of all existing lizards, some attaining the length of from six to eight feet.

2. *Chamæleons* are easily distinguished from the other members of this order by their peculiar tongue, which is long, fleshy, round, glutinous, and exsertile (*exsertus*, thrust out); they can project it at a fly with extraordinary rapidity. Their tail is prehensile; both eyelids unite to form a single circular eyelid, having an aperture in the centre. They are also remarkable for possessing the power of changing their colour.

3. *Iguanas* are known by their tongue, which is thick, fleshy, notched at its extremity, and non-protrusible—besides, there are generally present a dorsal crest and throat pouch (goitre). The body is covered with imbricated scales. They are sometimes divided into "ground iguanas," having a flattened head and depressed body, and "tree iguanas," in which the body is compressed laterally. It is stated that they can sometimes be tamed. Allied to the iguanas are the singular lizards called "flying dragons;" they are small, arboreal in their habits, and live upon insects. The anterior

ribs are strangely modified, inasmuch as they pass straight out from the spinal column, and support an expansion of the integument, which acts as a parachute, thus allowing the animal to take extensive leaps.

4. *Geckoes*, so called from the peculiar sound they utter, are nocturnal in their habits. They do not possess movable eyelids, but the eyes move freely behind a transparent fixed eyelid. Their toes are on each side provided with a leaf-like expansion, hence they can climb even vertical surfaces, or walk along the ceiling; it is supposed that this mechanism causes the toes to act as small suckers, and that the body is supported by atmospheric pressure when they walk along a ceiling; the toes are also sometimes furnished with retractile claws.

5. *Slow-worms* (blind-worms) are very snake-like in their external appearance, as they possess no limbs. The scapular and pelvic arches are, however, always present in a rudimentary condition; the eyes are provided with movable eyelids, having a longitudinal slit. When frightened, they can stiffen their muscles to such an extent that the tail can readily be broken off, as if it were brittle—hence they are called "angues fragiles." They are harmless, and live upon insects, slugs, &c., and remain under ground during the winter in a state of torpor.

III. Ophidia.—This order comprises all the snakes and serpents; they are true reptiles, as they possess no limbs whatever, and are known by the following characters:—The body is elongated, cylindrical, and covered with a scaly epidermic investment (there is never a bony exoskeleton present), which is generally shed in one piece, and reproduced at definite periods. In the rattle-snake this epidermic covering becomes modified at the extremity of the tail, and forms the rattle, which is composed of several

horny rings, loosely joined together. The number of vertebræ in the spinal column is considerable (amounting in some of the large pythons to more than four hundred), divided into caudal and præcaudal regions, there being no sacrum; the dorsal vertebræ are procœlous, and have rudimentary transverse processes. The sternum, scapular arch, and fore-limbs are always absent, and, as a rule, there are no traces of the hind limbs—rudimentary hind limbs are, however, represented in the pythons by a few imperfectly developed bones situated on each side of the anal vent in the muscles of the abdomen, which, when they project externally, are called "claws" or "spurs" (calcaria). The two rami of the lower jaw are composed of several pieces, united in front by ligaments and muscles only; the os quadratum is movable, and so are the mastoid and tympanic elements of the temporal bone; the maxillæ are united to the præmaxillæ by muscles and ligaments, and the arches of the palate are also movable. In consequence of this great mobility of all the bones surrounding the oral aperture, the ophidian reptiles are enabled to open their mouths to an enormous extent, and swallow their prey whole. The teeth in these animals are never placed in sockets, but are firmly anchylosed to the jaws; they are curved inwards, and are never used in mastication, but are simply employed in seizing and holding their prey. A very curious and interesting modification of the reptilian dental system occurs in the venomous snakes, where there are two poison-fangs united by movable joints to the superior maxillary bones, and communicating with the duct of a poison-gland, which is situated under and behind the eye. Each poison-fang is formed by a flexion inwards of a simple slender tooth (Owen), so as to form a tube, the opening of which is near the apex of the fang; when not in action, the fang lies in the gum pointed backwards, but, when its owner is about to bite, it is raised from the gum and pointed downwards—

at the same time the poison is expelled from the gland, partly by the contraction of the muscular walls of the gland, and partly by the muscles of the jaws, especially the temporals. This poison-gland is supposed to be one of the buccal salivary glands, modified in structure, so as to perform a different function; the poison secreted by it is a greasy, gelatinous, tasteless fluid, retaining its poisonous qualities for a long time if not exposed to heat, and drying in the air into scales; it is said to be harmless if swallowed. There are two or three other poison-fangs kept in reserve above and behind the one in use, ready to take its place if broken or destroyed. In most venomous reptiles there are no other teeth in the superior maxillary bones except the poison-fangs and their successors; in some, however, there are a few behind the poison-fangs, while all possess palatine teeth like the harmless snakes; lastly, in a few the terminal maxillary teeth are deeply grooved, but are not connected with the duct of any poison-gland. The ribs are very numerous and extremely movable, each terminated by a cartilage which is attached to the abdominal "scuta" by muscular connexions, and thus an ophidian reptile is said to walk on the extremities of its ribs. The heart has two auricles and one ventricle, the latter being imperfectly divided into two chambers by an incomplete septum. The lungs and other duplicate organs are generally symmetrical, one of each pair being rudimentary or absent. The urinary bladder is wanting; the aperture of the cloaca is transverse. The tongue is bifid and protrusible at will, and, when protruded, is in constant vibration; it is composed of two muscular cylinders united at their base, and is an organ of touch rather than of taste. The eye-ball is covered by a layer of transparent epidermis, attached circumferentially to a circle of scales (these scales are in lieu of eyelids), which is termed the "antocular membrane;" the posterior surface of this membrane is lined by a reflexion of the con-

junctival covering from the globe of the eye, forming a cavity called the "antocular cavity," into which is poured the lachrymal secretion by which the eye is moistened. The antocular membrane is periodically shed with the rest of the epidermis, thus rendering the animal blind for a few days. In most snakes the pupil of the eye is round, but in the venomous serpents and boas it is a vertical slit. Ophidia are sub-divided as follows:—

1. Viperinæ, with only two perforated fangs in upper jaw.
   - *e.g.*, Horned Viper—Africa.
   - „ Common Viper—England.
   - „ Rattle Snake—America.
   - „ Death Adder—Australia.
   - „ Puff Adder—Cape of Good Hope.

2. Colubrinæ, having solid teeth, with or without fangs in upper jaw.
   - *a.* Innocua, have solid teeth in upper jaw, no fangs.
     - *e.g.*, Ringed Snake (England),
     - „ Boas,
     - „ Pythons.
   - *b.* Suspecta, have fangs behind solid teeth.
     - *e.g.*, Homalopsidæ (ὁμαλή, smooth; and ὄψις, aspect).
     - „ Dipsadidæ (δίψα, thirst).
     - „ Dendrophidæ (δένδρον, a tree; & ὄφις, a snake)
   - *c.* Venenosa, have fangs in front of solid teeth.
     - *e.g.*, Cobra-di-capello
     - „ Hydrophidæ (ὕδωρ, water; and ὄφις).
     - „ Naia, Haje, Egypt

IV. Chelonia.—This order embraces a curious and interesting group of reptiles, comprising the turtles and tortoises. They are immediately recognized by the bony box which forms a protecting case for the body, within which the limbs and tail can almost always be withdrawn at

will, and generally the head as well; this bony box is composed of two portions, an upper portion called the dorsal shield, or "carapace," and a lower called the ventral, or "plastron." The carapace is formed by the spinous processes of the dorsal vertebræ, which are flattened out laterally, and constitute a series of broad plates, and by the ribs, which are also much expanded, forming what are termed the "costal plates." There are eight pair of ribs, generally, united along their lateral margins by sutures; in some instances, however, there are apertures at their extremities, which are covered by a thickened skin or horny plates. Along the margin of the carapace is placed a series of bones called "marginal plates," which are, by some, considered to be the ossified cartilages of the ribs, corresponding to the sternal ribs of birds, while others regard them as dermal bones belonging to the exoskeleton. The plastron, or ventral shield, consists of nine bony plates, of which eight are arranged in pairs, but the ninth is single, and occupies the mesial line, being always placed between the four pieces composing the two anterior pairs. By some the plastron is considered to be an enormously developed sternum, while others believe it to be composed of integumentary ossifications belonging to the exoskeleton. Both the carapace and plastron are covered, either with a leather-like skin, or, more usually, with a series of horny plates, which constitute in some species the "tortoise-shell" of commerce. All the bones of the head are immovably united together. In the adult, the lower jaw appears to consist of a single piece, as the different portions of which it had been composed in early life are firmly consolidated. The jaws are encased in horn so as to form a kind of beak; and teeth are entirely absent. The dorsal vertebræ, except the first, are immovably joined together, and there are no transverse processes; the cervical and caudal vertebræ present their wonted flexibility. The scapular and pelvic arches are, strange to say, situated inside the ribs, being

completely concealed within the bony box; the scapular arch consists of a clavicle, coracoid, and scapula, while the pelvic arch is formed by the ilium, ischium, and pubes. The heart consists of two auricles and a single ventricle, with an imperfect septum. The lungs are large, and respiration is effected by swallowing air, as in frogs. As most of the chelonie are phytophagous (φυτόν, a plant, and φαγεῖν, to eat), the alimentary canal is consequently long and complex; and, to economise space, is generally arranged in a direction transverse to the longitudinal axis of the body. The chelonie are long-lived, can remain without food for a lengthened period, and will, it is said, live for months after the complete removal of the brain, while portions of their bodies retain their irritability for a long time. They are divided, in accordance with the structure of their limbs, into—

Natatory Chelonie—*e.g.*, all Turtles.

Amphibious Chelonie { *e.g.*, Mud Turtles or Soft Tortoises (Tryonicidæ), Terrapins (Emydidæ).

Terrestrial Chelonie—Land Tortoises.

CHAPTER VI.

Amphibia.

Amphibia (Batrachia, Cuvier), also termed diplopnæa (διπλῆ. double; and πνοή, breathing), are known by the following characters:—They all possess branchiæ, which are either deciduous or permanent, hence, they have been divided into the *caduci-branchiata* and *perenni-branchiata*; true lungs are always present in the adult. There are always two occipital condyles for articulating with the vertebral column. The vertebral centra vary much, being amphicœlous in the ophiomorpha (ὄφις, a snake; and μορφή, form), opisthocœlous in the salamanders (σαλαμανδρα, a lizard), and procœlous in most of the others. When limbs are present, they are never converted into fins, but possess the same skeletal elements as those of the higher vertebrata. Their bones, both in chemical composition and in structure, are very similar to those of fishes; they have no medullary canal, no laminated arrangement, but the plasmatic canals exhibit slight dilatations, The heart, in the adult, consists of two auricles and a single ventricle. The nasal sacs communicate with the pharynx. The skin is smooth, glutinous, and almost always destitute of scales. There are never fin rays present, though median fins sometimes exist. There is a common cloaca. The embryo never possesses an amnion, and the urinary bladder represents the allantois. Lastly, they all undergo a metamorphose after leaving the egg. All amphibia commence their existence as water-breathing larvæ, provided with

branchiæ and possessing all the attributes of fishes; in some, only external branchiæ are present, in others both an internal and external set are developed; the external branchiæ are the first to disappear, and subsequently, when the lungs are fully developed, the internal. In the perenni-branchiata the external branchiæ are those that are retained. In the caduci-branchiata the following changes take place during the metamorphose of the larva: as soon as the branchiæ are fully developed the lungs make their appearance as simple sacs, which become elongated, and project backwards into the thoracico-abdominal cavity, and increase in proportion as the branchiæ shrivel and disappear. While this change is going on, the circulation is being altered from that of a fish to that of a reptile, in the following way:—The heart at first is similar to that of a fish, consisting of a single auricle, a single ventricle, and a bulbus arteriosus; the blood is propelled by the ventricle into the bulbus arteriosus, and thence, by the four branchial arches, to the gills, where it is purified; it then enters the branchial veins, which open into a large dorsal vessel called the aorta, and by this it is distributed to all parts of the body; the venous blood is now brought back by the veins to the auricle, and thence to the ventricle, to perform the same circuit. The first change now observed is the appearance of small vessels connecting each branchial arch with the descending aorta; these gradually enlarge, until all the blood passes through them; the three upper ones form permanent channels between the bulbus arteriosus and descending aorta; the fourth becomes the pulmonary artery as the lungs develop; pulmonary veins also make their appearance, connecting the lungs with a superadded auricle; as these alterations are going on, the course of the blood gradually assumes the type presented in reptiles. In the perenni-branchiata the three upper branchial arches convey blood to the gills, while the fourth becomes the pulmonary artery.

Amphibiæ are divided into the following four orders:—

1. Ophiomorpha (ὄφις and μορφή).
2. Urodela (οὐρά, a tail; and δῆλη, manifest).
3. Anoura (ἀ, not; and οὐρά).
4. Labyrinthodontia (λαβύρινθος, a labyrinth; and ὀδούς, a tooth).—Extinct.

I. Ophiomorpha, also termed gymnophiona (γυμνός, naked; and ὄφις), apoda (ἀ, not; and πόδα, a foot), ophidobatrachia (ὄφις, εἶδος, species; and βατράχιον, a frog), form a peculiar group of amphibians, containing only one family, the cæcilians (so called from their supposed blindness), and are known by the following characters:—Their body is elongated, annulated, and worm-like, totally destitute of limbs; the skin is soft, and generally has small horny scales imbedded in it; the eyes are rudimental or wanting. The vertebral centra are amphicælous; the rami of the lower jaw are short, and united in front by a symphisis; the teeth are long, and usually recurved; the ribs are numerous, but the sternum is absent; the tongue is fleshy and non-protrusible; the intestinal canal is long, and the anal outlet is near the termination of the body. In early life they have branchiæ, which disappear as the animal grows older, and breathes by means of lungs, one of which is smaller than the other. These curious animals are found in Java, Ceylon, Guinea, and South America, and were for a long time supposed to be reptiles, until the existence of branchiæ was discovered.

II. Urodela.—In this order, which has also been called icthyomorpha, sauro-batrachia, or lizard-like amphibians, and tailed amphibians (because the tail remains permanent), the body is elongated, and always destitute of an exoskeleton; they have either four feet or the two anterior

only; the dorsal vertebræ are either amphicœlous or opisthocœlous; and the transverse processes have short ribs connected to them. They are divided into—

1. Perenni-branchiata (amphi-neusta).	Proteus Anguinus.	Has the largest blood corpuscles yet discovered in the animal kingdom.
	Siren.	
	Menobranchus.	
2. Caduci-branchiata.	Water Salamander (Newt or Triton).	
	Land Salamander.	

III. Anoura, also called therio-morpha, batrachia, chelono-batrachia, or tortoise-like amphibians, have received their name from the fact that the adult possesses no tail. In all the members of this group the four limbs are present in the adult, and lungs perform the functions of the branchiæ of the larvæ. The vertebral column is short (there are only ten vertebræ in frogs), and the centra of the dorsal vertebræ are procœlous, and have long transverse processes attached to them. The hind limbs are, as a rule, larger and longer than the fore, and have their digits webbed. The tongue is attached to the symphisis of the lower jaw, but not to the os hyoides; respiration is carried on by swallowing air, so that a frog can be suffocated by keeping its mouth open. The skin is soft, and assists in purifying the blood by cutaneous respiration; and they finally undergo the following metamorphose:—The ova of the frog are laid in masses in the water, and the larvæ, on leaving the egg, are called tadpoles; these tadpoles have a large head, a long tail, and possess both external and internal branchiæ; the external branchiæ first disappear, and subsequently, when the lungs are fully developed, the internal. The hind limbs first appear (the reverse is the case in

the urodela), and then the fore limbs, which are formed in the branchial chambers; the tail then drops off, and the tadpole becomes a perfect frog. This order is divided into—

1. Frogs (ranidæ), have a tongue and teeth in upper jaw.
2. Toads (bufonidæ), have a tongue, no teeth.
3. Surinam Toads (pipidæ), have no tongue, and generally no teeth.

CHAPTER VII.

Pisces: General Characters.

Fishes form the last sub-division of the Vertebrata, and are destined solely for an aquatic mode of life. Their body is adapted for rapid motion in the water, and is covered by scales, which are either cycloid (κύκλος, a circle; and εἶδος, form), ctenoid (κτείς, a comb; and εἶδος), ganoid (γάνος, lustre; and εἶδος), or placoid (πλάξ, a flat surface; and εἶδος).—(Agassiz). The body of a fish is divided into the head, trunk, and tail; there is no neck, and the gills are placed behind the head. The fins are either symmetrical or asymmetrical:

1. Symmetrical.
   - *a.* Pectoral fins, homologous to fore limbs of other animals.
   - *b.* Abdominal fins, homologous to hind limbs of other animals.

2. Asymmetrical.
   - *a.* Dorsal.
   - *b.* Caudal.
   - *c.* Anal.

The limbs of fishes, when present, are always modified into fins, and depart widely from the limbs of the higher vertebrata. The anterior limbs, called the pectoral fins, are usually joined to the skull by the scapular arch, which consists of a supra-scapula, scapula, and coracoid bones; there is generally a bone (sometimes single, sometimes composed of two pieces) attached to the coracoid, and supposed to

represent the clavicle. The humerus is usually wanting, while the radius and ulna are connected to the coracoid; to these succeed a variable number of bones supposed to represent the carpus, and the carpus, in turn, is followed by the fin rays, which are believed to be homologous to the metacarpal bones and phalanges. In the flying fish the pectoral fins are enormously developed; the hind limbs, called the ventral fins, are often absent, and sometimes, as in the cod, are placed in front of the pectoral. In those fins there are no representatives of the femur, tibia, fibula, or tarsus; the "rays" unite directly with the pelvic arch, which is generally imbedded in the abdominal muscles, and is composed of only two bones supposed to represent the ischia. The dorsal and anal fins present nothing peculiar. The caudal fin, commonly called the tail, is always placed vertically, and is the chief motive power in progression; it is either *homo-cercal* (ὁμός, similar; and κέρκος, a tail) or *hetero-cercal* (ἕτερος, different; and κέρκος); the former most frequently appears in existing fishes, and consists of two equal lobes, while the vertebral column stops short at its base; the latter has the vertebral column prolonged into its upper lobe, so that it is unequally lobed. In the majority of fishes there exists a linear row of scales on each side of the body termed the "*lateral line;*" every scale in this line is perforated by a small duct opening into a longitudinal canal that runs along the entire length of the body, and communicates with certain cavities in the head. The use of this system is not known, for some state that it secretes mucus with which the body is covered, while others say that it is in some way connected with the sense of touch.

Osteology.—The endoskeleton in most of the recent fishes is entirely converted into bone; in some it is partly bony and partly cartilaginous; in others it is wholly cartilaginous; while in the amphioxus the noto-chord remains

persistent throughout the life of the animal. The cartilaginous fishes have a very small amount of earthy matter in their skeleton, so that their bones hardly deserve the name; they are extremely elastic and flexible, and, in chemical composition, are said to resemble inspissated mucus. The bones of osseous fishes are much harder than the preceding, but are more flexible than the bones of the other classes of Vertebrata; they have no medullary canals, a small amount of spongy tissue, and are never laminated in the arrangement of their component parts. In most fishes the plasmatic canals are free from partial dilatations—garpike (belone) and sea-bream (sargus) form exceptions. The vertebral column is divided into only two regions—an abdominal and a caudal; the vertebral centra are amphicœlous, except in the bony pike (lepidosteus), in which they are opisthocœlous; the margins of the contiguous vertebral centra are connected together by ligaments, and the cavities thus formed are filled with the gelatinous remains of the noto-chord, hence the extreme mobility of the entire spinal column. The abdominal vertebræ have a neural arch, a neural spine, and two transverse processes; the caudal vertebræ have, in addition to the neural arch, a hæmal arch and a hæmal spine, but no transverse processes. The ribs are imbedded in the muscles that surround the abdomen, and are connected to the transverse processes or bodies of the abdominal vertebræ at a single point; each rib generally gives off a styliform process of bone, which proceeds backwards amongst the muscles; there is no sternum. There is a series of dagger-like bones, called "interspinous bones," placed in the mesial line of the body between the lateral muscles; their internal points are generally situated between the spinous processes of the vertebræ, to which they are connected by ligament, while the fin-rays are joined to their opposite extremities by a peculiar joint, which will presently be described. Usually there is only one interspinous bone connected to the spinous process

of each vertebra, but in the flat-fishes (pleuro-nectidæ) there are two. There are two kinds of fin-rays, viz., the spinous rays and soft rays—hence fishes have been divided into acanthopterygii, those having spinous rays in their dorsal fins (ἄκανθα, a spine; and πτερύγιον, a little fin), and malacopterygii, in which all the rays are soft (μαλακόν, soft; and πτερύγιον). Every fin-ray is composed of two lateral pieces placed side by side; these are firmly united in the spinous rays, so as to simulate one bone, whereas in the soft rays they can be easily separated; each fin-ray articulates with its corresponding interspinous bone in a very peculiar manner, for the two pieces separate, so as to embrace the head of each interspinous bone, and end in blunt tubercles, which fit into depressions on each side of the interspinous bone; sometimes the interspinous bone is completely pierced, and the two pieces of the fin-ray meet, thus resembling the mode of union between the two links of a chain. The osteology of the skull of fishes is so intricate, and the opinions expressed by different authors concerning the homologies of the numerous bones forming the skull are so conflicting, that it is not my intention to discuss them in an elementary treatise such as this, but would refer the reader, desirous of information on this subject, to some of our larger standard works. The branchial apparatus shall, however, be briefly described in its proper place.

Digestion.—The mouth of fishes is generally furnished with a complicated series of teeth, which, in the bony fishes, are generally firmly* anchylosed to the bones that support them, and are not only developed on the jaw-bones, but also on the other bones which surround the buccal cavity. Salivary glands are entirely wanting; the œsophagus is

* The rostral teeth of the saw-fish are implanted in distinct sockets, as well as the teeth of a few others.

large and short, terminating in a well-defined stomach. The pyloric opening of the stomach is usually guarded by a valve; the intestinal canal is a simple tube commencing at the pyloric extremity of the stomach, and terminating at the anus or "vent." In the cartilaginous fishes the mucous membrane forms a spiral valve, winding like a screw from the pylorus to the anus, for the purpose of increasing the absorbent surface of the gut. The liver is generally large, soft, and saturated with oil; it occupies a large portion of the abdominal cavity, insinuating itself between the folds of intestine; a gall bladder is usually present. The pancreas in most fishes is represented by a number of "cæcal tubes," called the "pyloric cæca," or pyloric appendages; it is, however, present in the shark, ray, pike, eel, while in the sturgeon it exists along with the pyloric cæca, and in the lepidosiren both pancreas and pyloric cæca are wanting. The kidneys are usually very large, extending the whole length of the abdominal cavity; they are placed close to the spine behind the peritoneum, and are composed of minute uriniferous tubules, variously contorted, which terminate in the ureters; a species of bladder, opening behind the anus, is frequently formed by the ureters. Most fishes possess a peculiar organ called the "swimming bladder,"* which is supposed to be homologous to the lungs of the higher vertebrata, but not analogous. The swimming bladder is a sac containing gas, situated beneath the spine, to which it is bound by the peritoneum. The shape of this organ varies somewhat in different fishes; in most it forms an elongated sac; in many it is divided by septa; while in the lepidosiren it is composed of two sacs, divided into a number of cellular spaces, and in this fish is both homologous and analogous to the lungs of the air-breathing vertebrata. In many fishes the swimming bladder forms a closed sac; in others there is

* It is absent in the skate, flat-fishes, and mackerel.

a duct leading from it called the "ductus pneumaticus," which opens into the æsophagus (in the herring it opens into the stomach), and is homologous to the trachea of other vertebrata. The gas contained in this organ is secreted by its lining membrane, and is, in most fresh-water fishes, composed principally of nitrogen, and in sea fishes, of oxygen. The use of the swimming bladder is to alter the specific gravity of the fish, and to permit it to rise and sink in the water. This is accomplished by the alternate expansion and condensation of the contained gas, in consequence of either the relaxation and compression exerted by the abdominal walls, or of a muscular apparatus provided for the purpose.

Respiration.—On each side of a bony fish, immediately behind the head, there is a cavity called the branchial chamber, containing the branchiæ or gills, by means of which a fish respires; the external aperture of this chamber is covered by a large flap, called the *operculum*, which is constantly opening and shutting, to allow the escape of the water used in respiration. The bony framework of this large flap is formed by a chain of four broad flat bones, which have received the following names—*præoperculum*, *operculum*, *sub-operculum*, and *inter-operculum*. In addition to the operculum, the branchial chamber is also closed by a membrane, called the branchiostegal membrane (*βράγχια*, gills; and *στέγη*, a cover), which is attached to the hyoid bone, and supported by a number of slender spines connected to the sides of the hyoid bone, termed "branchiostegal rays." The branchiæ, or gills, are composed of delicate leaflets, covered with a vascular mucous membrane, and are attached to the outer surface of a series of bones, termed the "branchial arches;" these arches are usually four in number, and are connected with the hyoid bone below and the base of the skull above; their internal surfaces are generally studded with a series of processes which

prevent the food taken in by the mouth finding its way among the branchiæ, and thus interfering with the respiratory function. Respiration is accomplished in the following manner:—Water continually enters the mouth by a process analogous to swallowing, and then passes into the branchial chambers through a series of slits called branchial fissures, situated on both sides of the pharynx; the blood circulating through the branchial fringes robs of its oxygen the water, which finally escapes by the "gill slits" or "opercular aperture."

Circulation.—The heart* of fishes is a branchial or respiratory heart only, and consists of two cavities—an auricle and a ventricle. It is enclosed in a pericardium, and placed beneath the branchial apparatus. The blood takes the following course:—All the venous blood, coming both from the liver and body generally, is poured into the vena cava, which dilates into a large sinus before opening into the auricle; the auricular-caval opening is guarded by two membranous valves, which prevent regurgitation during the contraction of the auricle. The blood now passes into the ventricle through the auricular-ventricular opening, which is guarded by a strong mitral valve; from the ventricle arises a single artery called the branchial (also termed the right aortic arch); at its commencement this artery is dilated into a large sinus called the "*bulbus arteriosus*," which is separated from the ventricle by strong valves (in the shark tribe there are several rows of semilunar valves); the blood is propelled from the ventricle into the bulbus arteriosus, and thence through the branchial artery to the branchiæ, where it is purified; the radicles of the branchial

* The heart is absent in the amphioxus, while that of the lepidosiren has three chambers.

veins take up the blood now purified, and these veins, coming from all the branchial arches, ultimately coalesce to form the aorta, which distributes it to all parts of the body. The aorta runs beneath the spine in the abdomen, giving off the usual visceral branches, but on reaching the caudal vertebræ it enters the hæmal arch, through which it passes to its termination. It is remarkable that, while all the muscles of a fish are pale, or even white, the muscular fibres of the heart are red. The action of the heart is slow, averaging from twenty to thirty beats per minute, and in many fishes its irritability continues for a long time after death.

The Nervous System and Senses.—In fishes the nervous system presents a remarkable inferiority to that of the majority of vertebrate animals. The cavity of the cranium is small, and only partially occupied by the brain which consists of a collection of nervous ganglia, the first pair termed the olfactory lobes, the second pair the cerebral hemispheres, the third pair the optic lobes, and, lastly, a single ganglion resting on the medulla oblongata, and called the cerebellum. In addition to these, there are often present supplementary ganglia placed behind the cerebellum, supposed by some to be the anterior ganglia of the spinal cord greatly developed. All the cerebral nerves are present, with the exception of the ninth. The spinal nerves arise by double roots, the posterior roots, as in other vertebrata, being dilated into ganglia soon after their origin. The sympathetic system occupies the usual position, and communicates with the spinal nerves, but is small in comparison with that of other vertebrata. The olfactory nerves arising from the olfactory lobes vary in size and form in different fishes, nevertheless their destination is the same, viz., the olfactory chambers, which consist of two excavations situated near the tip of the snout, lined with a thin, plicated, pituitary membrane, behind which the nerve swells into a ganglion,

from which numerous filaments proceed to be distributed on the surface of this membrane. Into the cavity of the nose, which is usually divided by a septum into two chambers, the water passes freely, generally by a double aperture, sometimes by a single one; these nasal chambers form closed sacs, and never communicate with the pharynx, except in the lepidosiren and myxine, or hag-fish. The optic nerves arise from the optic lobes, and are composed of broad bands of nervous substance, folded up like a fan, and enclosed in a dense membrane; they decussate completely, forming no commissure, and finally terminate in the retina. The eye of a fish possesses tunics and dioptric media the same as in man, but modified to suit the different condition under which its possessor is placed—thus, the eye-ball is flattened from before backwards, and this shape is maintained by two cartilaginous plates imbedded in the sclerotic, while in some of the large fishes the sclerotic is converted into a cup of bone; the crystalline lens is spherical, and extremely dense, for the purpose of increasing the refraction of the rays of light, and is approximated to the retina at the expense of the vitreous humour. In many fishes the vitreous humour and lens are kept in position by a ligament called the falciform membrane, which passes from the retina through the vitreous humour, to be attached to the capsule of the lens. Behind the choroid coat there is placed an erectile organ called the "choroid gland," which is supposed to be of some use in arranging the focal distance of the lens. The pupil is large, but in the ray it is covered with a curtain, while in the anableps it is divided into two by a vertical septum forming a kind of natural stereoscope. The eye-ball is moved by six muscles, which have the same origin, distribution, and nervous supply as in man, except that the superior oblique does not pass through a pulley. The lachrymal glands and the eyelids are always wanting. The organ of hearing in fishes is very simple, and consists only of three semi-circular

canals and a membranous vestibule, containing a glairy fluid and certain bodies of a stony hardness called otoliths (in cartilaginous fishes the otoliths, or ear stones, are soft). The external ear, membrana tympani, tympanic cavity, ossicles, Eustachian tube, and cochlea, are entirely wanting. The sense of taste is believed to be extremely imperfect, if at all present, while that of touch is located chiefly in the soft parts surrounding the mouth.

The reproductive organs of osseous fishes present some remarkable points of interest. The ovary of the female, commonly called the roe, consists of a membranous bag, which at the spawning season becomes distended with ova, and occupies a considerable portion of the abdominal cavity. The ova, when mature, escape into the interior of the ovary, and are expelled through the oviduct, which opens either into the termination of the intestine, or by a distinct aperture situated behind the anus, and in front of the urinary canal. The testicle of the male, commonly called the "milt," or soft roe, consists of a multitude of seminiferous tubules, variously arranged in different fishes, but all terminating in a common duct. At the spawning season this organ becomes distended with a creamy fluid which is expelled into the water, and there vivifies the ova—thus, as a rule, the ova of osseous fishes are fecundated externally, but in a few, as, for example, the viviparous blenny, impregnation takes place internally. In the cartilaginous fishes, as well as in all other vertebrata, the ova burst through the capsule of the ovary, and enter the fallopian tubes, whence they are either directly expelled, or are retained and hatched internally. In sharks, rays, and dog-fishes, the ovum is protected by a horny case, which is secreted in the central portion of the oviduct; this case has four tendril-like cords attached to either corner, by means of which it is entangled in the sea-weed, and one of its extremities is open for the escape of the young animal. These cases are well known to

visitors at the sea-side by the name of "mermaid's purses." The males of these fishes are furnished with two prehensile organs termed "claspers," by means of which they hold the females during copulation.

CHAPTER VIII.

Pisces: Orders.

Naturalists have always experienced great difficulties in the classification of fishes, hence the variety of those proposed, and the confusion which has, in consequence, arisen. Subjoined are those now principally employed:—

1. Dipnoi (δίπνοοι, double breathing).
2. Elasmobranchii (ἔλασμα, a thin plate; and βράγχιον).
3. Ganoidei (γανός, lustre; and εἶδος).
4. Teleostei (τέλεον, perfect; and ὀστέον, a bone).
5. Marsipo-branchii (μάρσιπος, a pouch; and βράγχιον).
6. Pharyngobranchii (φαρυγξ, the throat; and βράγχιον).

(*Huxley.*)

1. Selachia (σέλας, brightness).
2. Ganoidei.
3. Teleostei.
4. Cyclostomata (κύκλος, a circle; and στόμα, mouth).
5. Leptocardia (λέπω, I strip off; and καρδία, the heart).

(*Müller.*)

1. Chondropterygii (χόνδρος, cartilage; and πτερύγιον).
2. Malacopterygii (μαλακόν, soft; and πτερύγιον).
3. Acanthopterygii (ἄκανθα, a spine; and πτερύγιον).

(*Cuvier.*)

1. Placoidei
2. Ganoidei.
3. Ctenoidei.
4. Cycloidei.

(*Agassiz.*)

It is intended, in the following pages, to adopt the classification proposed by Professor Huxley.

I. Dipnoi.—This order is believed to form the connecting link between the fishes and amphibians, and only includes that remarkable fish called the mud-fish or lepidosiren. For a long time this animal was placed among the amphibians, but is now, by almost universal consent, ranked with the fishes. The mud-fishes inhabit the marshy districts of Brazil and the east coast of Africa. During the rainy season they live as fishes in the swollen rivers, but when the dry season approaches they burrow into the mud, which is soon hardened by the sun—an aperture is, however, left for the admission of air. In consequence of this peculiarity in their mode of life, they possess some of the characteristics common to both fishes and amphibians. The body is shaped like that of a fish, and is covered with small, horny, cycloid scales; both the pectoral and ventral fins are present, but they have the appearance of awl-shaped filaments; the posterior part of the body, both above and below, has a median fin. This order of animals, as the name imports, breathes both by gills and lungs. The gills are situated in a branchial chamber, which opens externally by a vertical slit; the lungs are in the form of a double cellular air-bladder, which communicates with the œsophagus by means of the ductus pneumaticus. In the young there are external gills, which soon disappear. The nasal sacs open posteriorly into the pharynx; this also occurs in the myxines; in all other fishes they end in cul de sacs behind. The heart consists of two auricles and a single ventricle. The skull is composed of separate bones, and the noto-chord is persistent. There are only two species known, viz.:—

a. *Lepidosiren paradoxa*, from the Amazon.
b. *Lepidosiren annectens*, from the Gambia.

II. ELASMOBRANCHII, also called selachia (Müller), placoidei (Agassiz), include all the sharks, dog-fishes, rays, and chimæræ. The members of this order possess the following characters:—The endoskeleton, as a rule, is cartilaginous, (in the plagiostomi the vertebral centra are usually more or less ossified); the skull forms a cartilaginous box. The heart consists of an auricle and ventricle, and the bulbus arteriosus, which has several rows of transverse valves, is provided with a distinct layer of muscular fibres, and contracts rhythmically. The branchiæ are fixed and pouch-like, have no operculum or branchiostegal rays, and generally open externally by five vertical slits (in the holocephali, however, there is a single gill slit, and the operculum and branchiostegal rays are rudimentary). The intestine is short, and has a fold of mucous membrane passing in a spiral manner from the pyloric extremity of the stomach to the anus. The integument has, irregularly scattered through it, detached grains or tubercles of bony matter. Both the pectoral and ventral fins are present, the latter being placed near the anus. The teeth in this order are very variable in their form, but there is a striking peculiarity in those of the sharks; in these there are several rows of teeth placed one behind the other, the front row composed of triangular cutting teeth, and when these are worn out, the succeeding row take their place, and so on. This order is sub-divided into—

(*A.*) *Holocephali* (ὅλη, whole; and κεφαλή, head).—The only existing representatives of this sub-order are the chimæridæ; they are known by the following characters:—The chorda dorsalis is persistent, but the transverse processes and neural arches are cartilaginous; the gills open by a single aperture externally, and the mouth is placed at the extremity of the head. They include—

a. Chimæra monstrosa, or King of the Herrings.

b. Callorhyncus australis, or Southern Chimæra.

(*B.*) *Plagiostomi* (πλάγιον, transverse; and στόμα, mouth), containing the well-known shark and ray. In this sub-order the vertebral column is more or less ossified; the mouth is placed on the under surface of the head, and is transverse; the branchiæ open externally by five vertical gill slits; two tubes pass from the pharynx, and open on the upper part of the head by two openings named "spiraclea." They are divided into—

α. *Cestraphori* (κέστρα, a pointed weapon; and φέρω, I bear)—*e. g.*, Port Jackson Shark.
β. *Selachii*—*e. g.*, Sharks and Dog-fishes.
γ. *Batides*—*e. g.*, Rays.

III. Ganoidei.—These were very numerous in former geological periods, but are now represented by only a few existing forms. They are all covered with ganoid * scales, plates, or spines, which are composed of a superficial layer of ganoine, a substance somewhat similar to enamel, resting on a layer of bone. The endoskeleton is generally cartilaginous, but sometimes more or less ossified, and in the bony pike (lepidosteus) the vertebræ are more completely ossified than in any other existing fish, while the vertebral centra are opisthocœlous. The bulbus arteriosus contracts rhythmically, and has several transverse rows of valves; the intestine frequently has a spiral valve. The caudal fin is usually "hetero-cercal;" the gills are free, and covered by an operculum. The swimming bladder is always present, often divided by septa into several cells, and opens into the gullet by the ductus pneumaticus. Both pectoral and ventral fins are usually present, the latter placed far back. This order is sub-divided by Professor Owen into—

* The plecto-gnathi and lopho-branchii among the teleostei also have ganoid scales and plates.

a. Lepido-ganoidei (λεπίς, a scale; γάνος and εἶδος)—*e.g.*, Bony Pike (lepidosteus) and Polypterus.

b. Placo-ganoidei (πλάξ, a flat surface; γάνος and εἶδος), *e.g.*, Sturgeon.

IV. TELEOSTEI.—This order comprises the majority of existing fishes, and is characterized by the possession of a more perfectly ossified endoskeleton than the other orders (bony pike excepted). A teleostian fish having been already taken as the type in the general description of the class pisces, it is not necessary to recapitulate the leading characters of this order; its sub-divisions are—

(*A.*) ***Malacopteri*** (μαλακόν, soft; and πτερόν, a fin), or physostomata (φυσάω I puff; and στόμα, the mouth), having soft rays,* swim bladder; ductus pneumaticus, and generally cycloid scales.

1. Apoda—no ventral fins.
   - Murænidæ—Eels.
   - Gymnotidæ—Electric Eels.
   - Symbranchidæ—Fresh water tropical fishes.
2. Abdominalia.
   - Esocidæ—Pikes.
   - Clupeidæ—Herrings.
   - Cyprinidæ—Carps.
   - Salmonidæ—Salmon, Trout.
   - Siluridæ—Sheat-fishes.

(*B.*) ***Anacanthini*** (ἀ, not; and ἄκανθα, a spine), having soft rays, ventral fins, either absent, or, if present, placed beneath the throat; no ductus pneumaticus; swim bladder sometimes absent.

1. Apoda.
   - Ammodytidæ (ἄμμος, sand; δύω, I sink in; and εἶδος, form), Sand Eels.
   - Ophididæ (ὄφις, a snake, and εἶδος), Snake-like Eels (Mediterranean)
2. Subrachiata.
   - Gadidæ — Cod, Haddock, Ling, Whiting, &c.
   - Pleuronectidæ (πλευρόν, the side; νήχω, I swim; and εἶδος), Sole, Plaice, Turbot.

* The first rays in the dorsal and pectoral fins are sometimes spiny.

(*C.*) *Acanthopteri* (ἄκανθα, a spine; and πτερόν, a fin, have one or more of the first rays in fins spiny, swim bladder has no duct, scales usually ctenoid..	Cyclolabridæ—Wrasses. Percidæ—Perches. Mugilidæ—Mullets. Gobiidæ—Gobies. Scomberidæ—Mackerels. Sclerogenidæ—Gurnards. Blenniidæ—Blennies. Lophiidæ—Anglers.
(*D.*) *Plectognathi* (πλέκω, I weave; and γνάθος, the jaw), maxillary and præmaxillary bones immovably united, ganoid scales and plates.	Balistidæ—File-fishes. Gymnodontidæ (γυμνός, naked; ὀδούς, a tooth; and εἶδος)—Globe-fishes. Ostracionidæ (ὄστρακον, a shell; and εἶδος)—Trunk-fishes.
(*E.*) *Lophobranchii* (λόφος, a tuft; and βράγχιον), have tufted gills and ganoid scales.	Hippocampidæ—Sea-horses. Syngnathidæ—Pipe-fishes.

V. Marsipobranchii (Cyclostomata).—The members of this order possess an elongated, cylindrical body. The symmetrical fins are always absent; the chorda-dorsalis remains persistent; the skull is cartilaginous, and there is no lower jaw. The heart consists of an auricle and ventricle only, there being no bulbus arteriosus. The gills are in the form of small pouches, opening externally by a series of apertures, and communicating internally with the pharynx. They are divided into—

a. Hag-fishes (myxinidæ), have a sucker-like mouth, furnished with tentacles, and a single serrated fang attached to the palate, by means of which they penetrate the bodies of other fishes, amongst which they are found. The nasal sacs communicate with the pharynx.

b. Lampreys (petromyzonidæ) (πέτρος, a stone; μυξάω, I suck; and εἶδος), have a sucker-like mouth, but no tentacles. The gills open externally by seven apertures, and lead internally into a common tube, which, in turn, opens into the

pharynx; in consequence of this arrangement respiration goes on, though the lamprey may be fastened by its mouth to a stone.

VI. PHARYNGOBRANCHII.—This order only contains a single fish called the amphioxus lanceolatus, which is the lowest member of the vertebral sub-kingdom. In this animal the skull, lower jaw, symmetrical fins, and heart, are entirely wanting. The chorda-dorsalis is persistent; the mouth is in the form of a longitudinal slit, surrounded with cirri, and leads into a ciliated pharynx, which performs the functions of a respiratory organ. The water that enters the mouth passes through this branchial chamber, and then goes through a number of slits on either side into the cavity of the body, and finally escapes by the abdominal pore, which is situated in front of the anus.

End of the Vertebrata.

INVERTEBRATA.

CHAPTER IX.

INVERTEBRATA.—SUB-KINGDOM.—MOLLUSCA.

WE shall now briefly describe the succeeding sub-kingdoms included by Lamark in one great division, which he designated Invertebrata; and although they differ widely from each other in various particulars, they are all distinguished from the Vertebrata by the following characters:—(1.) The entire absence of a vertebral column, lacteal and lymphatic systems, as well as portal venous system. (2.) There is no endoskeleton; when a skeleton is present it is always external, and is called the exo-skeleton; in the cephalopoda, however, the most highly organized of the mollusca, there is an attempt at a rudimentary endo-skeleton in the form of the "cuttle bone" or "pen." (3.) There is only one nervous system, which is supposed to be similar to the sympathetic system of the Vertebrata. (4.) The limbs, when present, are always, directed towards the neural side of the body. (5.) The different organs, so easily demonstrated in the Vertebrata, become variously modified, and gradually disappear, until we arrive at the lowest of the Protozoa, where we find a living animal composed of a single cell, without any organ whatever, and not even possessing an oral or anal aperture. The following are the sub-kingdoms now most generally recognised:—

Mollusca (*mollis*, soft).
Molluscoida (*mollusca*; and εἶδος, form).
Annulosa (*annulus*, a ring).
Anuloida (*annulus* and εἶδος).
Cœlenterata (κοίλα, hollow; and ἔντερα, intestines).
Protozoa (πρῶτη, first; and ζωή, life).

It will be seen that we do not arrive at the protozoa by a direct line, but by two distinct routes. In the ensuing pages it will be more convenient to describe the molluscoida as a division of the mollusca, not as a distinct sub-kingdom.

MOLLUSCA are soft-bodied animals, having a soft and moist skin, termed the mantle, which usually secretes a calcareous covering or shell, hence they are popularly called "shell-fish" (in the naked mollusca the shell is absent). The shell is composed of carbonate of lime, and all recent shells are covered with a layer of animal matter, termed the "epidermis" or "periostracum." The shells of molluscs are either univalve, bivalve, or multivalve; they are non-vascular, and grow by the addition of layers to their circumference; if too small, they may be cast off and reproduced; when broken, the fractured extremities cannot unite by any material produced by the shell itself, but are cemented together by newly-formed shell substance secreted by the mantle. As regards their conformation, three principal varieties of shell are enumerated, viz., the "nacreous" (*nacre*, pearl) or "pearly shell," the "porcellaneous" (*porcelaine*, china), and the "fibrous." The digestive apparatus consists of a mouth, gullet, stomach, intestine, and anus; in a few of the lower forms the intestine ends in a cæcal extremity.

The respiratory function is performed by branchiæ in the aquatic forms—by air sacs in the terrestrial. The heart, in the higher mollusca, is systemic, and consists of an auricle and ventricle; the blood is colourless, or has a greenish tinge, and is contained in vessels.

The nervous system, in the mollusca proper, consists of three principal ganglia, called the "*cerebral*," "*pedal*," and "*parieto-splanchnic*," connected together by commissures, hence they have been called "*hetero-gangliata*" (ἕτερόν, odd; and γάγγλιον) (Owen); the names given to these ganglia

indicate their position and the parts they supply; the gullet is, moreover, surrounded by a nervous collar. In the lower mollusca there is only a single ganglion, giving off filaments in various directions. Organs of smell, sight, and hearing, are believed to exist in all the mollusca proper.

Reproduction is almost always sexual, the sexes being usually distinct, but sometimes united in the same individual. The colonies, however, of the polyzoa and tunicata are produced by a process of continuous gemmation. The mollusca are sub-divided into the mollusca proper and the molluscoida. Some naturalists have, however, raised the molluscoida to the rank of a distinct sub-kingdom. The mollusca proper are sub-divided as follows:—

1. Odontophora (*ὀδούς*, a tooth; and *φορός*, bearing), encephala (*ἐγκέφαλος*, brain), or cephalophora (*κεφαλή*, a head; and *φορός*).	Cephalopoda (*κεφαλή*, and *πούς*, the foot). Gasteropoda (*γαστήρ*, the stomach; and *πούς*). Pteropoda (*πτέρον*, a wing; and *πούς*).
2. Acephala (*ἀ*, not; and *κεφαλή*), or headless.	Lamelli-branchiata (*lamellæ*, leaves; and *branchiæ*, gills).

I. Cephalopoda.—All the members of this order are marine, carnivorous, and possess great power of locomotion. They have eight or more arms surrounding the mouth. The body is enveloped in a muscular mantle sac, or gill sac, within which are two or more gills; the anterior orifice of this sac is termed the "*funnel*," or *infundibulum*, through which the effete water of respiration is expelled, as well as the residue of the food, for the anus opens at the base of the funnel. The body is symmetrical, and divided into an anterior or cephalic portion, and a posterior or trunk containing the viscera. The head is provided with a pair of large eyes, while the mouth is surrounded by eight or more arms, which are usually furnished with rows of suckers or "acetabula;"

these arms are supposed to be formed by a splitting up of the margins of the foot. Locomotion is accomplished by the cephalopod either walking at the bottom of the sea with the head downwards, or expelling water from the mantle sac, by means of which the animal is propelled in the opposite direction, or by swimming with the lateral expansions of the mantle (these expansions are not, however, always present). The majority of existing cephalopods possess no shell. The mouth leads into a cavity containing two strong horny jaws, working vertically like the beak of a parrot, and an *odontophore*, or lingual ribbon, covered with recurved spines. Many possess a peculiar gland called the "*ink-bag*," that secretes a dark fluid, which the animal, when pursued or frightened, discharges into the water, thus wholly concealing itself from view; the duct of this gland opens at the base of the funnel. The supra-æsophageal ganglia are protected by cartilage supposed to be a rudimentary cranium, while the "*cuttle bone*" or "*pen*" is believed to be the first appearance of an endo-skeleton. The cephalopoda are subdivided into—

1. Dibranchiata (δύο, two; and βράγχια, gills)
   - Octopoda (ὀκτώ, eight; and πούς, the foot). — Paper Nautilus (argonauta), has an external shell. Octopus (poulpe).*
   - Decapoda (δέκα, ten; and πούς) — Calamary (loligo), Squid.

2. Tetrabranchiata (τέτταρα, four; and βράγχια).
   - Pearly Nautilus (pompilius), has an external shell.
   - Ammonites, Orthoceras — Extinct.

II. Gasteropoda.—In this class the shell is generally univalve, never bivalve, sometimes multivalve, while in

* My friend Staff-Surgeon Boileau has informed me that, on three different occasions, officers of the 29th Regiment, when stationed in Malta, were followed by poulpes.

many it is either absent, or so small as to escape observation. The spiral univalve shell most frequently occurs in this class, and consists of a number of coils or whorls generally surrounding a central axis; the last coil of the shell is called the mouth or body whorl; if it be entire, the animal has lived on vegetable food; if notched, on animal food. The foot is greatly developed, and often has a horny or shelly "*operculum*," which is for the purpose of closing up the mouth of the shell when the animal retires within. The head is usually distinct, and has two feelers and two eyes often situated upon stalks. The mouth possesses an "odontophore" or "lingual ribbon," and sometimes horny jaws as well. The mouth conducts by the gullet into a stomach, which, in some, is provided with calcareous plates for triturating the food. The sub-divisions of this order are—

1. Pulmo-gasteropoda or Pulmonifera (*pulmones*, lungs; and *fero*, I bear), having pulmonary chambers or lungs formed by an inflexion of the mantle.	*e.g.*, Land Snail (Helix), Slug and Pond Snail.
2. Branchio-gasteropoda or Branchiferæ (βράγχια, gills; and φέρω, I bear), having branchiæ or gills.	*e.g.*, Limpet, Sea-lemon, Heteropoda, Periwinkle, Whelk, &c.

III. PTEROPODA are extremely small marine molluscs, and constitute the principal food of the whale; they subsist near the surface of the sea, at a distance from land, and occur in great numbers. They have two wing-like appendages attached to the sides of the head, which are believed to be formed by a modification of a portion of the foot. They generally have a thin glassy shell; in some, however, there is no shell.

LAMELLI-BRANCHIATA.—These have been sometimes denominated acephalous, or headless molluscs, also conchiferæ, or bivalve shell-fish. The two valves of the shell are always

"right" and "left," usually equivalve (though the oyster forms an exception) and inequilateral. The apex of the valve is called the "*umbo*," or "beak," and is directed towards the mouth of the animal. The shell is shut by one, or more commonly two adductor muscles, which leave distinct marks in the shell of the animal when dead, and is opened by the hinge ligament when the muscles relax; all these animals are aquatic, and breathe by leaf-like gills, which, in the oyster, are commonly known as the "beard." The sexes are usually distinct. In some—as, for example, the mussel—a viscous fluid, termed "*byssus*," is secreted by a special gland, by means of which they can fasten on any solid substance. This class includes the familiar oysters, scallops, cockles, mussels, &c.

Molluscoida.

All the members included in this division are aquatic. The nervous system consists either of a single ganglion or a pair, with accessary ganglia situated near the mouth. There is sometimes only one opening, which is used both for an oral and anal aperture; when both are present, they are situated close to each other. The sub-divisions are—

1. Brachiopoda.
2. Tunicata.
3. Polyzoa.

I. Brachiopoda (*βραχίων*, the arm; and *πούς*, the foot).—These are all marine molluscs, and live at great depths in the sea; they are protected by a bivalve shell, which is "dorsal," and "ventral," and "inequivalve;" they were formerly called "*lamp-shells*," in consequence of a muscular stalk passing through a hole in the apex of the ventral valve, by means of which the shell is fastened to a rock; this stalk was supposed to resemble the wick of a lamp; sometimes, however, the stalk passes between the valves of the shell.

There are two long ciliated arms attached to the sides of the mouth, which procure food for the animal, and act as respiratory organs—hence their name, brachiopoda.

II. TUNICATA (*tunica*, a coat).—These molluscs are often called ascidioida (*ἀσκίδιον*, a little bottle; and *εἶδος*, form), and are commonly known as sea-squirts. They are small marine animals, very like a double-necked leather bottle, and are often collected together in colonies. The external investment of their body is called the "*test*," and contains a substance almost identical with the vegetable product called "cellulose;" inside the "test" there is a muscular coat which confers on the animal the power of squirting out the water. The oral aperture is usually surrounded with a circle of ciliated tentacles, and leads into a chamber called the "pharynx," or "respiratory sac," which occupies the greatest part of the body; the sides of this chamber are perforated by numerous ciliated apertures, and communicate with a second chamber, termed the "atrium" or "cloaca," which opens externally by the "atrial" aperture. From the pharynx, or "respiratory sac," there comes off a gullet which opens into a stomach; this, in turn, leads to the intestine, which terminates in the atrial chamber. Thus the atrial chamber receives both the effete water of respiration, and also the contents of the intestine. The tunicata possess a heart of simple construction, as it consists of a muscular tube open at both ends; its action, however, is very peculiar, for it propels the blood alternately in opposite directions. All these animals are stationary, and possess one nervous ganglion between the oral and anal apertures.

III. POLYZOA (*πολλά*, many; and *ζῷα*, animals).—The members of this class are popularly known as "sea-mats" or "sea-mosses;" they are sometimes called bryozoa (*βρύον*, sea-weed; and *ζῷα*), and are known to geologists by the

name of "*lace corals.*" They form compound colonies, produced by gemmation from a single individual or zooid; they are termed "polypides," and are protected by a horny integument. The body of each individual zooid is covered by an "ectocyst" and "endocyst," which are perforated by two openings, an oral and anal. The oral aperture is surrounded by ciliated tentacles, which perform the office of a respiratory organ, as well as induce a current in the water for the purpose of conveying particles of food to the mouth. The mouth and tentacles can be withdrawn into the interior of the animal by a special muscle attached to the gullet. The mouth leads into a gullet which, in turn, opens into the stomach, from which proceeds an intestine that terminates by the anal opening near the mouth. There is a single nervous ganglion situated between the mouth and anus. A sea-mat, which is often mistaken by sea-side visitors for a piece of sea-weed, is in reality the skeleton of a colony of these animals, for each little chamber or cell that it contains was originally occupied by a single zooid. The skeleton is sometimes covered with little organs called "birds' head processes," which are continually snapping together, but their use is unknown. There is no distinct heart. They are all hermaphrodite, and multiply by ova or by gemmation.

CHAPTER X.

ANNULOSA.

THE members of this sub-kingdom have received the name Annulosa in consequence of their annulated or ringed appearance; they have also been called *Homogangliata* (ὁμοῦ, together; and γάγγλια, ganglia—Owen), and *Articulata* (*articulatus*, jointed—Cuvier). The body is composed of a series of segments, (*somites*), arranged in a longitudinal manner. The limbs, when present, are turned towards the neural aspect of the body. The alimentary canal is distinct, and does not communicate with the general body cavity. Respiration is performed either by the general surface of the body, or by "tracheæ," "pulmonary sacs," or "branchiæ." Circulation is effected either by a systemic heart, consisting of one ventricle, or a single segmented dorsal vessel, or a pseudo-hæmal system; or the blood circulating system may be absent. The nervous system is situated on the ventral aspect of the body, and consists, in its typical form, of a pair of symmetrical ganglia in each segment (anterior cephalic segment excepted), which are connected by two nervous cords that extend along the whole length of the animal. The most anterior ganglion is single, and called the supra-æsophageal or cerebral. The sense of sight exhibits some extremely interesting gradations, and the following different kinds of eye are met with:—(1.) The eye spot.—In the lowest members of this sub-kingdom, the

annelida (*anellus*, a little ring; and εἶδος, form), we find the organ of vision existing in its simplest form, and termed an "ocellus," or "eye spot." This ocellus is formed by a single optic nerve passing from the supra-æsophageal ganglion, and expanding into a retina behind a delicate transparent integument that serves the purpose of a cornea; situated immediately posterior to the retina there is a single pigmentary or choroid coat—such is the structure of an ocellus wherever met with in the animal kingdom. (2.) The simple eye.—This form of eye, found in the insecta, crustacea, and arachnida, consists of an external coat formed by the choroid, which, bending down in front, constitutes an iris with a central opening or pupil; inside this there is a retina, vitreous humour, and globular lens, in close contact with a minute, smooth, convex cornea. (3.) The conglomerate eye.—It is composed of a number of simple eyes massed together, and is found in the myriapoda (μυρίοι, innumerable; and πόδες, feet). (4.) The compound eye.—Its structure is extremely intricate, and conflicting accounts of it have been given by different accurate observers. The following is the most generally received opinion concerning its formation:—The optic nerve, immediately after its origin from the supra-æsophageal ganglion, swells into a secondary ganglion; from this secondary ganglion arise a great number of short nerves, which terminate by forming a nervous expansion called the "*general retina*," situated behind a pigmental layer called the common choroid; a multitude of minute filaments arising from the general retina pierce the common choroid, and terminate in a number of separate corneal facettes, each filament ending in a single cornea; the corneal facettes are described as hexagonal lenses united together. This form of eye is found among the insecta and crustacea, and it is stated that the common house-fly possesses about 4,000 of those distinct corneal facettes in each compound eye.

The other senses, though present, become more rudimentary and imperfect as we descend through the different members of this sub-kingdom. The remaining peculiarities, especially those of reproduction, will be mentioned in describing the different classes. The Annulosa are divided into—

I. Arthropoda (ἄρθρον, a joint; and πούς, the foot).
II. Anarthropoda (ἄνευ, without; ἄρθρον and πούς).

I. Arthropoda.—The members of this division are more correctly denominated articulate animals, because they have jointed appendages articulated to the body. The covering of the body is either a "chitinous" integument or calcareous shell, from the inner surface of which the muscles arise. In the embryo the nervous system always presents the true homogangliate type, although in the adult it may be variously modified. Ciliæ are never present. The Arthropoda are sub-divided into—

1. Insecta.
2. Arachnida.
3. Crustacea.
4. Myriapoda.

1. Insecta (*inseco*, I cut into).—This class is extremely numerous, and is said to contain more species than all the rest of the animal kingdom, no less than 150,000 having been already described. Insects can easily be recognised by the following characters:—The body is covered by an integumentary envelope, more or less hardened with "chitine," and is divided into three distinct parts, viz., the head, thorax, and abdomen. The head, formed of several smaller segments amalgamated together, supports a pair of eyes, usually compound, a pair of antennæ (feelers), of mandibles, and maxillæ. The thorax, composed of three segments, *prothorax*, *mesothorax*, *metathorax*, carries two or four wings

(the wings are often absent, sometimes deciduous), and three pairs of legs. The wings are composed of a double membranous expansion of the integument, supported by "nervures" (*nervus*, a sinew), and are attached to the dorsal surface of the meso-thorax and meta-thorax. The legs are always six in number, a pair being connected to each segment of the thorax. Each leg is composed of a series of pieces named in order, coxa, trochanter, femur, tibia, and tarsus; the tarsus contains two to six, generally five joints, terminated by claws. The abdomen, composed of nine segments amalgamated together, contains the viscera and organs of reproduction—never carries legs, and sometimes has peculiar appendages, such as the forceps of the earwig, the stings of bees and wasps, the ovipositors of the ichneumon. The muscles are striped, and arranged in small bundles or fasciculi without sarcolemna; they are extremely numerous, Lyonnet having described nearly 1,800 in the larva of the goat moth.

The digestive apparatus consists of (1) mouth, (2) pharynx, (3) œsophagus, (4) crop (in masticatory insects), (5) proventriculus or gizzard, (6) ventriculus or stomach, (7) intestine, (8) cloaca. There are two distinct types of mouth found in insects, viz., the masticatory, and suctorial or haustellate; these are sometimes modified, and occasionally combined. The masticatory mouth (*e.g.*, beetles) consists of (1) labrum or upper lip, (2) a pair of mandibles or biting jaws, (3) a pair of maxillæ or chewing jaws, with one or more pairs of maxillary palpi, (4) a labrum or lower lip, with labial palpi. In the suctorial mouth (butterflies) the labrum and mandibles are rudimentary; the maxillæ are elongated, and form a spiral tube (proboscis), while the labial palpi form two hairy cushions, between which the proboscis is received when not in use. The gizzard is muscular, and often has ridges on its internal surface, furnished with plates of "chitine" for crushing the food.

The glands present are (1) salivary, (2) malpighian, or biliary tubes, (3) uriniferous tubes opening into the cloaca. *Respiration* is effected by "trachea," or air tubes, that open externally by apertures called "spiracles," and as they pass inwards through the tissues, they branch and anastomose; inside these tubes there is a filament of "chitine," coiled in a spiral manner. Many insects undergo an interesting metamorphose before arriving at maturity. Take, for an example, the common butterfly; on leaving the egg the insect is termed a larva, but is better known by the name of caterpillar. This caterpillar has an elongated, worm-like body, with numerous legs; it eats ravenously, increases rapidly in size, and frequently changes its skin; after changing its skin for the last time the animal wraps itself up in a case called the *cocoon*, and becomes perfectly quiescent and torpid; it is now called a *chrysalis*, *nympha*, or *pupa;* in this state it remains for some time, often for many months, and then bursts through its covering, and becomes the *imago*, or perfect insect, that alone has the power of propagating the species; having accomplished this duty it dies. A peculiar method of reproduction has been particularly described by Professor Owen under the name of *Parthenogenesis* (παρθένος, a virgin; and γένεσις, production), or the power of propagation, "sine concubitu;" it is well exemplified in the aphides, or plant lice, sic.:—In the autumn only do perfect male and female insects make their appearance; at this time the female becomes impregnated, and produces true ova, which, lying dormant throughout the winter, are hatched in spring, and become developed into female aphides, which in turn produce other females, without any coitus, to the ninth, tenth, or perhaps eleventh generation; when the final generation again appears in autumn perfect males and females once more make their appearance, and so on. A variety of this form of propagation occurs in the bee. Every bee-hive contains from fifteen to twenty thousand

workers (neutral females), about six hundred drones (males), and one queen bee, or perfect female; once in four or five years the queen bee selects a mate from among the drones, and by this single act of coitus the innumerable ova to which she subsequently gives birth are impregnated; the drones are now killed and expelled from the hive as useless. The following account of the construction of the bee-hive is taken from Dallas:—"We never, however, except at the period of swarming, meet with more than one female in the hive. The whole duty of the construction of the comb and the care of the young devolve upon the workers, whose incessant activity has rendered them the most appropriate types of industry. The comb, as is well known, consists of beautiful hexagonal cells, constructed with mathematical accuracy; it is perpendicular, and composed of a double series of cells placed end to end in such a manner that the end of each cell is closed by three waxen plates, each of which also assists in completing one of the cells of the other side of the comb. By this arrangement the greatest possible number of cells may be constructed in a given space with the smallest amount of material. In these cells the eggs are laid; here also the larvæ are brought to maturity by the care of the workers; and when no longer required as nurseries for the young, they are employed as a store for honey. The eggs which are to give birth to males are placed in cells a little larger than those of the workers. Those from which females, or queens, are to be produced are deposited in cells of peculiar construction, and the larvæ are fed upon a different food from that of the workers. When the population of the hive has grown too large, a portion of the workers emigrate, accompanied by a young queen. This is termed "*swarming.*"

Insects have been divided into the following orders:—

Ametabolic (ἀ, not; and μεταβόλος, changeable).

1. Anoplura (ἄνοπλος, unarmed; and οὐρά, tail)—*e.g.*, louse (pediculus).
2. Mallophaga (μαλλός, wool; and φαγειν, to feed)—Bird louse.
3. Thysanura (θύσανος, a fringe; and οὐρά, the tail—Spring tail (podura).

Hemi-metabolic (ἡμι. half; and μεταβόλος).

4. Hemiptera (ἡμι; and πτερόν, a wing)—Plant lice (aphides).
5. Orthoptera (ὀρθόν, erect; and πτερόν)—Cockroach (blattina).
6. Neuroptera (νεῦρον, a sinew; and πτερόν)—Dragon flies (libellulidæ).

Holo-metabolic (ὅλος, whole; and μεταβόλος).

7. Hymenoptera (ὑμήν, a membrane; and πτερόν)—Bees and wasps.
8. Aphaniptera (ἀφανῆ, unseen; and πτερά, wings)—Flea (pulex).
9. Diptera (δύο, two; and πτερὰ)—House fly (musca).
10. Lepidoptera (λεπίς, a scale; εἶδος, form; and πτερὰ)—Butterflies, moths.
11. Strepsiptera (στρέφω, I twist; and πτερὰ)—Stylops.
12. Coleoptera (κολεός, a sheath; and πτερὰ)—Beetles.

The first three orders undergo no metamorphose whatever; the next three undergo a partial metamorphose; while the last six undergo a complete one.

2. Arachnida (ἀράχνης, a spider; and εἶδος).—The members of this class are easily distinguished by the following characters:—The head is always united to the thorax, so as to constitute a cephalo-thorax; the integument is usually hardened with chitine, but sometimes remains soft; there are always four pair of legs, never more; wings are always absent, and the abdomen never has limbs of any kind con-

nected to it. The majority of the arachnida are adapted for a terrestrial life, but some, as the sea spiders (formerly believed to be crustacea), are formed for an aquatic life. As the arachnida live chiefly by imbibing the juices of their victims, their mouth is adapted for piercing and suctorial purposes, and, in the higher forms, consists of a pair of "mandibles," a pair of "maxillæ," and a "labium." In the scorpion there is a labrum; the mandibles end in pincers; while the maxillary palpi form "chelæ," or nipping claws. The alimentary canal is short and straight. Salivary glands, uriniferous tubes, and biliary vessels have been described. Respiration is usually effected either by "pulmonary sacs" or "tracheæ;" in some of the lowest members of the class there are no distinct respiratory organs, consequently this function must be performed by the general surface of the body. The circulation is generally carried on by a dorsal heart, which is often elongated; in the lower grades, however, there is no distinct organ of circulation. The nervous system, though of the homogangliate type, is often concentrated. When organs of vision are present, they consist of from two to eight simple eyes. Many of the araneida or spiders that belong to this class possess the power of constructing a web, and in order to accomplish this there is a special gland, situated at the extremity of the abdomen, that secretes a viscid fluid, which hardens when exposed to the air, and is fashioned into its thread-like form by passing through minute tubes called "spinnerets." All spiders are carnivorous; their mandibles are hooked, and have the duct of a poison-gland connected to them.

The Arachneida are divided into—

I. Trachearia (*trachea*, the wind-pipe).

a. Adelarthrosomata (ἀ, not; δῆλον, manifest; ἄρθρον, a joint; and σῶμα, the body)—Harvest Spiders, Book Scorpions.

b. Acarina (*ἄκαρι*, a mite)—Mites, Ticks.
c. Podosomata (*πούς*, the foot; and *σῶμα*)—Sea Spiders.

II. Pulmonaria (*pulmones*, lungs).
a. Araneida (*aranĕa*, a spider)—Spiders.
b. Pedipalpi (*pes*, the foot; and *palpo*, I strike)—Scorpions.

3. Crustacea (*crusta*, a crust) comprise a large number of animals that are more or less aquatic, and covered with a hard, chitinous envelope, or a partially calcareous exoskeleton. The body of a typical Crustacean consists of twenty-one somites placed one behind the other; the first seven constitute the head, the second seven the thorax, and the remaining seven the abdomen; frequently the first fourteen somites are amalgamated together to constitute a cephalo-thorax. The head carries two pair of antennæ. The limbs are more than eight in number, and are generally connected to the abdomen as well as to the thorax. The alimentary canal throughout all the Crustacean families is extremely simple, and consists of a mouth, œsophagus, stomach, and a short intestine. Taking the lobster as the most familiar example, we find that the mouth, surrounded by modified limbs or "foot jaws," leads into a short œsophagus that terminates in a globular stomach containing a calcareous apparatus for triturating the food, commonly called the "*lady*;" the intestine is straight, and terminates by the anal orifice, which is situated in front of the last segment of the abdomen, called the "*telson*." Respiration is accomplished usually by gills, sometimes by the general surface of the body. The circulation is carried on in the higher Crustacea by a dorsal heart containing a single cavity—in the lower by a long dorsal vessel. The nervous system, though possessing the homogangliate type, especially in the embryo, is greatly concentrated in the adult. The sense of sight is well developed, and both simple, conglomerate, and compound eyes are met with. The repro-

ductive organs always exist in different sexes, and the young crabs and lobsters cast their shell ("moult") frequently before arriving at maturity.

Crustacea are sub-divided as follows:—

Malacostraca (*μαλακα*, soft; and *ὄστρακά*, shells).

- I. Decapoda (*δέκα*, ten; & *πούς*, foot).
  - *a.* Macrura (*μακρά*, long; and *οὐρά*, a tail)—Lobster.
  - *b.* Brachyura (*βραχεῖα*, short; and *οὐρά*)—Crab.
  - *c.* Anomoura (*ἄνομος*, irregular; & *οὐρά*)—Hermit Crab.

  Podopthalmata (*πούς*, foot; and *ὀφθαλμός*, the eye), or stalked-eyed.
- II. Stomapoda (*στόμα*, mouth; and *πούς*)—Locust Shrimp.
- III. Amphipoda (*ἀμφί*, on both sides; and *πούς*)—Sand-hoppers.
- IV. Isopoda (*ἴσος*, equal; and *πούς*)—Wood-lice.
- V. Læmodipoda (*λαιμός*, throat; and *πούς*)—Whale-louse.

  Edriophthalmata (*ἕδραῖος*, sitting; and *ὀφθαλμός*), or sessile-eyed.

Entomastraca, shelled insects (*ἔντομα*, insects; and *ὄστρακα*).

- VI. Merostomata (*μέρος*, a division; and *στόμα*, the mouth)—King Crabs.
- VII. Phyllapoda (*φύλλον*, a leaf; and *πούς*)—Apus.
- VIII. Cladocera (*κλάδος*, a branch; and *κέρας*, a horn)—Daphnia.
- IX. Copepoda (*κώπη*, a handle; and *πούς*)—Cyclops.
- X. Ostracoda (*ὄστρακον*, a shell)—Cypris.
- XI. Trilobita (*τρεῖς*, three; and *λοβός*, a lobe)—Extinct
- XII. Cirripedia (*cirrus*, a filament; and *pes*, the foot)—Acorn Shells and Barnacles.
- XIII. Epizoa (*ἐπί*, upon; and *ζῷα*, animals)—Lernæa (parasitic).

4. MYRIAPODA (*μυρίοι*, innumerable; and *πόδες*, feet).—This class has received the name it bears in consequence of

the numerous feet which its members possess. The body always consists of more than twenty segments, each segment carrying one or two pair of articulated legs. There is no clear line of demarcation between the thorax and abdomen. The head, however, is distinct, and carries one pair of antennæ. The body segments increase with the age of the animal, and are covered with a semi-calcareous or coriaceous integumentary envelope. The alimentary canal is distinct. Respiration is performed by "tracheæ." Circulation is carried on by a dorsal vessel or heart. The nervous system consists of a ventral chain of ganglia of the homogangliate type. The sexual organs are in different individuals. The eyes are conglomerate. The sub-divisions of this class are—

1. Centipedes (*centum*, a hundred; and *pedes*, feet).
2. Millipedes (*mille*, thousand; and *pedes*).

1. Centipedes (scolopendridæ) are carnivorous, have from fifteen to twenty pair of legs, and their antennæ have not less than fourteen joints each. Their mouth is provided with a pair of horny jaws and a pair of curved perforated poison-fangs. The bite of the European species is harmless, but some of those in the tropics attain a large size, and can inflict a dangerous bite.

2. Millipedes (julidæ) live chiefly on decaying vegetable matter, have numerous legs (more than twenty pair), and their antennæ have never more than six or seven joints each. They are perfectly harmless, and live in dark, damp places, beneath stones or the wood of decaying trees.

II. ANARTHROPODA (ἄνευ, without; ἄρθρον, a joint; and πούς, the foot).—In this division the locomotive appendages are either absent, or, if present, are never distinctly articulated to the body. They are divided into—

I. Anellida (*anellus*, a little ring; and εἶδος, form.)
II. Gephyrea (γέφυρα, a bridge).

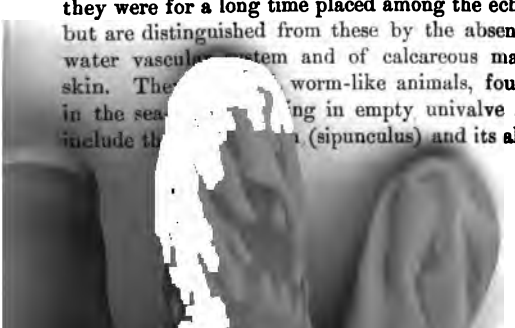
I. **Annellida** are annulated worm-like animals, covered with a soft integumentary envelope. The segments of the body (leeches excepted) are provided with appendages which are never articulated to the body, and they are usually adapted for the purpose of locomotion. The alimentary canal is distinct and straight, consisting of a mouth, œsophagus, stomach, and intestine, the latter terminating in a distinct anus that is usually situated at one extremity of the body. Respiration is performed by branchiæ, or by the general surface of the body. Many have involutions of the integument, called "respiratory pouches" or "segmental organs," supposed to be engaged in the function of respiration. Circulation is carried on by a set of vessels termed pseudo-hæmal (*ψευδές*, false; and *αἷμα*, blood), supposed to be homologous to the "water vascular" system of the Annuloida; there is no distinct contractile dorsal vessel. The nervous system consists of a double chain of ventral ganglia, presenting the homogangliate type. The organs of sense are extremely simple. The embryos are usually ciliated, and often undergo a metamorphose. The organs of reproduction are sometimes distinct, sometimes they are united in the same individual. The sub-divisions of this order are—

I. Branchiata (*branchiæ*, gills).
   a. Tubicola (*tubus*, a tube; and *colo*, I inhabit), marine, living in tubes, *e.g.*, Serpula.
   b. Errantia (*errans*, wandering), marine, always free, *e.g.*, Sea-mouse (aphrodite), Lob-worm (arenicola piscatorum), Hairy-bait (nephthys).

II. Abranchiata (*a*, not; and *branchiæ*).
   a. Hirudinea, *e.g.*, Leeches.
   b. Oligochæta (*ὀλίγη*, little; and *χαίτη*, hair), *e.g.* Earth-worms (lumbricidæ), Water-worms (naid[illegible]

The Hirudinea, also called suctoria and discophora (δίσκος, a disc; and φόρος, bearing), comprise the well-known leeches or *blood-suckers*. They are all aquatic, some living in fresh water, others in the sea. They have, at one or both extremities of the body, a sucking disc, by means of which they creep along in a very peculiar way. Their body is distinctly ringed; the alimentary canal is short, has lateral dilatations, and is connected to the integument by a vascular spongy tissue. Respiration is performed by the general surface of the body, and by the respiratory pouches; there are no branchiæ. The pseudo-hæmal system consists of four longitudinal vessels united by lateral branches. The nervous system presents the usual homogangliate type. There are eight or ten ocelli, arranged in a semicircle above the mouth on the surface of the sucking disc. The leech, though hermaphrodite, cannot impregnate its own ova, but, strange to say, requires the presence of a second leech for that purpose. The medicinal leech (sanguisuga officinalis) has three semicircular serrated teeth, by means of which it pierces the skin; its bite is perfectly harmless, but that of some of the tropical leeches (*e.g.*, hirudo zeylanica) is very severe, and liable to be followed by dangerous sores. The horse leech has no teeth.

II. Gephyrea (γέφυρα, a bridge) have received this name in consequence of their forming the bridge, as it were, or connecting link between the annelids and holothurians—in fact, they were for a long time placed among the echino-dermata, but are distinguished from these by the absence both of a water vascular system and of calcareous matter in their skin. The[illegible] worm-like animals, found imbedded in the sea[illegible]ng in empty univalve shells. They include th[illegible] (sipunculus) and its allies.



CHAPTER XI.

ANNULOIDA.

ANNULOIDA (*annulus*, a ring; and εἶδος, form), also termed by Professor Owen, Nematoneura (νῆμα, a thread; and νεῦρον, a nerve).—The members of this and the succeeding sub-kingdoms live either in water or in the interior of other animals; none of them enjoy a free terrestrial existence. The Annuloida are known by the following characters:—They all possess a distinct set of vessels, which have received the name of the "water vascular" or "aquiferous" system. The alimentary canal, when present, is distinct, and usually has both an oral and an anal aperture. A nervous system is present, the ganglia being arranged symmetrically. They often exhibit in their reproduction what is termed "alternation of generation" (*vide* Appendix). They are divided into—

1. Echinodermata.
2. Scolecida.

1. ECHINODERMATA (ἐχῖνος, a hedgehog; and δέρμα, a skin).—The members of this group always have their integument more or less hardened by calcareous matter. An alimentary canal is always present. The water-vascular system is termed the "*ambulacral*" (*ambulo*, I walk) system, because it is often used in locomotion. The nervous system forms a ring round the gullet, from which branches proceed to the different parts of the body. They are divided into the following orders:—

I. HOLOTHURIDEA (ὁλοθούριον; and εἶδος, form).—Body elongated and worm-like; integument thick and contractile, often destitute of calcareous matter; mouth surrounded by tentacles; a distinct anus always present; ambulacral system sometimes rudimentary. The members of this order are commonly called sea "cucumbers" or "trepangs."

II. ECHINOIDEA (ἐχῖνος, a hedgehog; and εἶδος, form).—Body covered with a "test" or shell, composed (in all existing forms) of ten calcareous zones. The five larger zones are imperforate, and termed "*inter-ambulacral areas;*" the five smaller ones are perforated with holes for the ambulacral tube feet, and termed "*ambulacral areas.*" The test is covered with tubercles carrying spines. The mouth is guarded by five teeth, popularly called "*Aristotle's lantern.*" The members of this order are commonly called "sea hedgehogs," "sea urchins," or "sea eggs."

III. ASTEROIDEA (ἀστρον, a star; and εἶδος).—Body star-shaped, consisting of a central portion, surrounded with five or more arms, containing prolongations from the stomach; integument thick, and hardened with calcareous matter. Nervous system truly radiate; oral and anal apertures present. The members of this order are popularly known as "star-fish."

IV. CRINOIDEA (κρίνον, a lily; and εἶδος, form).—Body covered by calcareous matter, and fixed during the whole or a portion of the animal's existence by a flexible stalk. There are five or more arms; alimentary canal has both an oral and anal aperture. The members of this order were formerly numerous, but are now scarce; they comprise the "feather stars" or "sea lilies."

V. OPHIUROIDEA (ὄφις, a serpent; οὐρα, a tail; and εἶδος).—Body circular, to which are attached five arms that do not contain prolongations of the stomach; integument hardened

with calcareous matter. There is an oral aperture, but no anal. This order contains the sand stars and brittle stars.

VI. Cystoidea (κύστις, a bladder; and εἶδος). } Both these
VII. Blastoidea (βλάστος, a shoot; and εἶδος). } orders are extinct.

2. Scolecida (σκώληξ, a worm; and εἶδος).—The animals comprised in this division never have their integument hardened with calcareous matter. The alimentary canal is frequently absent, and the nervous system is very rudimentary, consisting only of one or two ganglia. They all, however, possess a water-vascular system. Many are internal parasites, and are reproduced by an alternation of generations. They are divided into—

Platyelmia (πλατεῖα, broad; & ἕλμινς, a worm).

- I. Tæniada (*ταίνια*, a band). — *e.g.*, Tape-worms; all are parasitic, and have no alimentary canal (*vide* Appendix).
- II. Trematoda (*τρηματώδης*, perforated). — „ Flukes, parasitic; alimentary canal has only one aperture.
- III. Turbellaria (*turbo*, I disturb). — „ Planarians, aquatic; alimentary canal has only one aperture in the majority.

Nematelmia (νῆμα, a thread; and ἕλμινς).

- IV. Nematoidea (*νῆμα*; and *εἶδος*, form). — „ Thread-worms, free and parasitic; alimentary canal has two apertures.
- V. Acantho-cephala (*ἄκανθα*, a thorn; & *κεφαλή*, the head). — „ Thorn-headed worms, parasitic; alimentary canal absent.
- VI. Gordiacea. — „ Hair-worms, parasitic in insects; alimentary canal has only one aperture.
- VII. Rotiferæ (*rota*, a wheel; and *fero*, I bear). — „ Wheel animalcules, aquatic, microscopic; alimentary canal has two apertures.

CHAPTER XII.

CÆLENTERATA.

CÆLENTERATA (κοῖλον, hollow; and ἔντερον, intestine).—All the members of this sub-kingdom are aquatic, and commonly called "zoophytes" (ζῷον, an animal; and φυτόν, a plant), or plant-like animals, in consequence of the striking resemblance which many of them bear to plants, often resembling flowers in their appearance. The body is composed of a soft, sarcode substance, covered externally by a membrane named the "ectoderm," and internally by the "endoderm." In nearly all the ectoderm is furnished with peculiar microscopic organs, termed "cnidæ," "nematocysts," "thread-cells," or "nettle-cells," which confer on these animals the urticating or stinging property so well known to all sea-bathers in the case of the common jelly-fish. The alimentary canal communicates with the general body cavity, and has only one aperture, which performs the duties of both mouth and anus. There are no distinct organs of respiration and circulation. The nervous system, when present, consists of a solitary ganglion, from which small filaments take their origin. Ocelli and auditory sacs are, for the last time, met with in this sub-kingdom. Reproduction is either sexual, non-sexual (fission or gemmation), or both. They are divided into—

1. Hydrozoa (ὕδωρ, water; and ζῷα, animals).
2. Actinozoa (ἀκτίς, a ray; and ζῷα).

1. HYDROZOA.—These animals have no distinct digestive cavity—in other words, the body cavity and digestive cavity are identical, and the organs of reproduction are situated on the external surface of the body. They are divided into the following orders:—

I. Acalephæ (*ἀκαλήφη*, a nettle—Medusæ), *e.g.*, Jelly-fish or Sea-nettles.
II. Hydræ (*ὕδωρ*, water), *e.g.*, Fresh-water Polyps.
III. Sertularidæ (*sertula*, a plant; and *εἶδος*, form,) *e.g.*, some Sea Firs and their allies.
IV. Campanularidæ (*campanula;* and *εἶδος*), *e.g.*, do., do.
V. Tubularidæ (*tubus*, a tube; and *εἶδος*), „ Corynidæ.

2. ACTINOZOA.—These animals have a distinct digestive cavity that opens into the general body cavity, and is separated from the body walls by the "perivisceral" space. The organs of reproduction are internal. The following orders are included in this class:—

I. Actinæ (*ἀκτίς*, a ray), *e.g.*, "Sea Anemones," "Animal Flowers."
II. Alcyonidæ (*ἀλκυόνειον*, bastard sponge), *e.g.*, "Dead men's toes," "Cow paps."
III. Madreporidæ, *e.g.*, Tree Corals.
IV. Corallidæ (*κοράλλιον*, coral; and *εἶδος*), *e.g.*, Corals.
V. Pennatulidæ (*penna*, a pen; and *εἶδος*), „ "Sea pens."
VI. Rugosæ (*rugosus*, shrivelled).—(Extinct).

CHAPTER XIII

Protozoa.

Protozoa (πρῶτα, first; and ζῷα, animals).—This sub-kingdom forms the last and lowest division of the animal world, and comprises a vast number of animals, the great majority of which are microscopic, and are commonly termed "animalcules;" the sponges, however, form an important exception. They are entirely composed of a simple jelly-like substance called sarcode (σάρξ, flesh; and εἶδος, form), and have no distinctive organs whatever—in fact, they are chiefly known by negative characteristics. A distinct alimentary canal and nervous system are totally wanting, hence the members of this sub-kingdom are called acrita (ἀ, not; and κρίνω, I discern); separate organs of respiration, circulation, vision, and audition are also absent. This sarcode, or, as it has been termed, protoplasm, of which they are composed, usually possesses the power of active locomotion and contractility; it sometimes contains only minute granules or molecules, often a nucleus or nucleolus, and frequently small cavities called "contractile vesicles," supposed by some to be rudimentary organs of circulation. They are generally gemmiparous or fissiparous in their reproduction; some, however, multiply by sexual intercourse. They are divided into—

1. Stomata (στόμα, the mouth).
2. Astomata (ἀ, not; and στόμα).

1. Stomata comprise those minute animalcules that are frequently found in organic infusions, and are consequently denominated infusoria. It is still "sub judice" whether

they are developed from pre-existent, undiscovered microscopic germs, or are produced by what has been termed "spontaneous generation" from the materials existing in the organic infusion; be that as it may, they undoubtedly exist and constitute the most highly organised division of the Protozoa. All the infusoria possess a mouth (the acineta has many mouths, hence the name polystome—πολύ, many; and στόμα, a mouth—given to this order by Professor Greene), and are furnished with vibratile ciliæ; the mouth does not open into any distinct digestive cavity, but into the soft sarcode of which the animal is composed. Spaces named vacuoles are found in this sarcode, which Ehrenberg believed to be stomachs, hence he named them polygastrica (πόλλη, many; and γαστήρ, a stomach). They are divided into—

I. Ciliata (cilium), *e.g.*, Epistylis, Paramœcium.
II. Suctoria (*sugo*, I suck), *e.g.*, Acineta.
III. Flagellata (*flagellum*, a whip), *e.g.*, Peranema.
IV. *Noctiluca (*nox*, night; and *luceo*, I shine), *e.g.*, Noctiluca miliaris.

2. Astomata.—This division of the Protozoa comprises those animals in which there is no mouth whatever; they are first divided into—

1. Rhizopoda. 2 Gregarinidæ.

1. Rhizopoda (ῥίζα, a root; and πούς, the foot).—These animals are characterised by the peculiar property which they possess of throwing out processes of sarcode called pseudo-podia (ψευδής, false; and πούς). They are divided into the following orders:—

I. Spongida (σπόγγος, a sponge; and εἶδος, form).—These animals consist of a framework of horny fibres, or of calcareous or flinty processes, covered with the sponge flesh.

* Principally cause the luminosity of the sea.

There are numerous holes leading into the "aquiferous" canals that permeate the sponge in all directions, and through which the water circulates, carrying food, which is taken from it by the pseudo-podia belonging to every individual sponge particle. The great majority of the holes are small, and are called "pores" or "inhalant apertures;" by these the water enters. A few of the holes are large, and are termed "oscula" or "exhalant apertures;" through these the water is ejected. The sponge has been compared, by Professor Huxley, to "a kind of sub-aqueous city where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along." This circulation is maintained by cilia waving towards the interior of the sponge.

II. RADIOLARIA (*radius*, a ray) are small marine animals, composed of a jelly-like sarcode that has the power of throwing out long thread-like pseudo-podia, and of secreting a silicious or flinty skeleton, either in the form of a shell or of separate spicules. This order includes three families, viz.: Acantho-metrina (ἄκανθα, a thorn; and μέτρον, measure), Polycystina (πόλλη, many; and κύστις, a bladder), and Thallasicollida (θαλάσσα, sea; and κόλλα, glue).

III. FORAMINIFERA (*foramen*, an aperture; and *ferens*, bearing).—The members of this order consist of a simple sarcode substance that has the power of throwing out long thread-like pseudo-podia, which interlace with each other so as to constitute a net-work termed "animated spider's web." The body is always protected by a shell or "test," which is either calcareous, *i.e.*, formed of carbonate of lime, or "arenaceous," *i.e.*, formed of sand, welded together by an animal cement. These shells are either mono-thalamous (μόνος, single; and θάλαμος, a chamber), single-chambered, or polythalamous (πόλυς, many; and θάλαμος), many-cham-

bered. They are arranged in two great divisions, depending on the absence or presence of small foramina in the shell wall, viz., imperforata and perforata. The great chalk cliffs of the south of England are almost entirely composed of microscopic shells of this order, while the stone of which Paris is built is mainly composed of the shells of these animals.

IV. AMÆBEA (*ἀμοιβαῖος*, interchanging).—This order is so named in consequence of its members constantly changing their shape; they are all minute aquatic animals. Their body is composed of a simple sarcode substance, containing a nucleus and contractile vesicle, and has the power of throwing out pseudo-podia that are generally blunt.

2. GREGARINIDÆ (*gregarius*, occurring in numbers) are minute unicellular animals, living as parasites in the alimentary canal of vertebrate and invertebrate animals, and frequently found in the intestines of the cockroach and earthworm. The body consists of a single cell, containing granules of sarcode, a nucleus and nucleolus, and does not possess the property of emitting pseudo-podia.

FINIS.

APPENDIX.

APPENDIX.

HUMAN PARASITES.

The best and most concise description of the parasites that infest the human subject, that I am aware of, is to be found in Dr. Aitken's celebrated *Practice of Medicine*, from which I have copied the following tabulated arrangement of the Entozoa, and where full information on this interesting subject can be obtained.

ENTOZOA.

"A. SOLID WORMS :—PLATYLMIA ; vel, STERELMINTHA.

I. CESTOIDEA—Banded, riband-like, girdled, or tape-worms, in the form of—

1. Mature sexual parasites, androgynous, and living in the alimentary canal.

(a.) *Tæniæ.* 1. *Tænia solium* (LINNÆUS), the common tape-worm of man in this country.

2. „ *mediocanellata* (KUCHENMEISTER), the common tape-worm of man on the Continent.

3. „ *marginata* (BATSCH, COBBOLD).

4. „ *elliptica* (BATSCH, COBBOLD).

5. *Tænia acanthotrias* (WEINLAND, COBBOLD), its larva, scolex, or cysticercus only known.
6. „ *nana* (SIEBOLD), a very small filiform *Tænia*.
7. „ *flavopunctata* (WEINLAND, COBBOLD).
8. „ *echinococcus* (SIEBOLD).

(b.) *Bothriocephali*. 1. *Bothriocephalus latus* (BREMSER); vel, *T. lata* (LINNÆUS), the broad tapeworm, endemic to man in some localities only. Its embryo is ciliated and developed in water (KNOCH).

2. *Bothriocephalus cordatus* (LEUCKART), new to science; recently found in North Greenland.

2. Immature non-sexual, cystic, or vesicular parasites, the embryonic form of the genera sub (a.) *Tæniæ*.

(a.) *Cysticerci*. 1. *Cysticercus tæniæ cellulosæ* (RUDOLPHI), the larva or scolex of the *T. solium*.

2. „ *tæniæ mediocanellatæ* (LEUCKART), the larva or scolex of *T. mediocanellata*.
3. „ *tenuicollis* (RUDOLPHI), the larva of *T. marginata*.
4. „ *tæniæ ellipticæ*, at present unknown.
5. „ *tæniæ acanthotriæ* (WEINLAND), only the cysticercus found; mature *Tænia* not yet found.
6. „ *tæniæ nanæ*, at present unknown; probably inhabits insects (LEUCKART).

7. *Cysticercus tæniæ flavopunctatæ*, also at present unknown.

(b.) *Echinococci.* 8. *Echinococcus hominis* (RUDOLPHI), the larva of *Tænia echinococcus*.

II. TREMATODA—Fluke-like parasites.

1. *Fasciola hepatica* (LINNÆUS); vel, *Distoma hepaticum* (RUDOLPHI).
2. *Distoma crassum* (BUSK); vel, *Distoma Buskii* (LANKESTER).
3. *Distoma lanceolatum* (MEHLIS).
4. *Distoma ophthalmobium* (DIESING).
5. *Distoma heterophyes* (SIEBOLD).
6. *Bilharzia hæmatobia* (COBBOLD); vel, *Gynæcophorus hæmatobius* (DIESING).
7. *Tetrastoma renale* (DELLA CHIAJE).
8. *Hexathyridium pinguicola* (TREUTLER).
9. *Hexathyridium venarum* (TREUTLER).

B. HOLLOW WORMS:—NEMATELMIA; vel, CŒLELMINTHA.

I. ASCARIDES—Unisexual, body attenuated posteriorly, and still more so anteriorly, mouth with *three* tubercles, tail of the male narrower than that of the female.

1. *Ascaris lumbricoides* (LINNÆUS).
2. *Ascaris mystax* (RUDOLPHI, COBBOLD); vel, *Ascaris alata* (BELLINGHAM).
3. *Trichocephalus dispar* (RUDOLPHI).

II. OXYURIDES—Unisexual, body more attenuated posteriorly than anteriorly, rudimentary tubercles round the mouth, tail of male thickened.

1. *Oxyuris vermicularis* (BREMSER).

III. TRICHINÆ—Unisexual, cystic, and free.

1. *Trichina spiralis* (OWEN).

IV. SCLEROSTOMA—Unisexual, body slightly attenuated anteriorly, mouth with four hooks, tail of male cup-shaped.

1. *Sclerostoma duodenale* (COBBOLD); vel, *Ancylostoma duodenale* (SIEBOLD).

V. STRONGYLUS—Unisexual, body attenuated posteriorly, mouth with six lobes, tail of male cup-shaped.

1. *Strongylus bronchialis* (COBBOLD); vel, *Filaria bronchialis* (RUDOLPHI).
2. *Eustrongylus gigas* (DIESING); vel, *Strongylus renalis* (MOQUIN-TANDON).

VI. SPEROPTERA—Unisexual, tail spiral, and furnished with marginal appendices.

1. *Speroptera hominis* (RUDOLPHI).

VII. FILARIÆ—Unisexual, body equal (filiform), mouth with three tubercles, tail simple.

1. *Filaria lentis* (DIESING); vel, *Filaria oculi humani* (NORDMANN).
2. *Filaria medinensis* (GMELIN).

C. A third class may provisionally be regarded as accidental Parasites. These are—

Pentastoma constrictum (lung, liver; W. Coast of Africa).

Anthomia caricularis, larva, exciting causes of boils.

Pentastoma denticulatum vestris hominis (SIEBOLD), liver and small intestines."

EPIZOA.

Class.	*Order.*	*Genus.*	*Species.*
Insecta.	Anoplura.	Pediculidæ.	Pediculus capitis. „ pubis. „ corporis. „ palpebrarum. „ tabescentium.
Arachnida.	Acarina.	Acaridæ.	Acarus scabeei. *Demodox folliculorum.

* By some Naturalists the Demodox is ranked among the Acaridæ, by others among the Rotiferæ.

Alternation of generation, or *Metagenesis*, first described by Steenstrup, is well exemplified in the development of the tænia solium, or common tape-worm. This worm, when mature, inhabits the intestines of the human subject. It consists of a minute head, terminating in a convexity, surrounded with a double row of hooks; posterior to this convexity there are situated four equi-distant cups or suckers. The head is followed by a slender neck that presents transverse markings, and to this succeeds the body, which consists of a number of similar segments, termed *Zoonites*, or *Proglottides*. Each segment is hermaphrodite, contains numbers of ova, and is expelled in this state per rectum. Every mature ovum is protected by a leathery capsule, which ensures its vitality for a long time after the segment has disappeared by putrefaction. The majority of these ova perish, but some are swallowed by other animals; and when one of these ova is swallowed by the pig an embryo is set free, termed a proscolex, provided with three pair of spikelets, by means of which it makes its way to some resting place, or perchance it may enter a mesenteric vein, and be carried by the blood to the liver; in either case it becomes encysted and constitutes a *cysticereus*, or *echinococcus*, the embryo *per se* being called a *scolex*. In this condition some transverse lines may make their appearance on its neck, indicative of future segmentation, when it is technically termed a *strobila embryo*. It never reaches any further stage of development, unless it is swallowed by man, when it becomes developed into the perfect tænia solium. Accordingly, it passes through the following stages, viz. :—*ovum*, *proscolex*, *scolex*, *strobila embryo*, and *tænia solium*. Man generally becomes infested with the tape-worm from eating diseased pork, for these worms constitute the disease called *measles* in the pig.

REPRODUCTION.

I have here copied from Dr. Mapother's work on Physiology a tabulated arrangement of the several methods of reproduction, framed by Professor A. Thomson, to which Dr. Mapother has added an example of each.

NON-SEXUAL.

"FISSIPAROUS—Parent splits, each part a new animal.

1. Transverse—*Amœba.*
2. Longitudinal—*Vorticella.*
3. Irregular—*Gonium.*

Parent splits and discharges the young—*Volvox.*

"GEMMIPAROUS—Budding upon the parent stock—*Hydra.*

Separated buds. Gemmæ or sporules.

1. On all parts of the body—*Medusa.*
2. On one part or organ only—*Tunicata.*

SEXUAL.

"HERMAPHRODITE—Both sexual organs on one individual.

1. Self-impregnation—*Tape-worm.*
2. Mutual impregnation—*Snail.*

"DIÆCIOUS—Oviparous, laying eggs which are hatched.

1. External fecundation—*Herring.*
2. Internal fecundation—*Fowl.*

Ovo-viviparous. Eggs hatched within the maternal body—*Snake.*

Mammiferous, suckling the young.

1. Monotrematous—*Ornithorynchus.*
2. Marsupial—*Kangaroo.*
3. Placental, or strictly viviparous—*Man.*"

EXAMPLES

OF THE KIND OF QUESTIONS ON

ZOOLOGY AND COMPARATIVE ANATOMY,

GIVEN BY SOME OF THE

PRINCIPAL EXAMINING BOARDS IN ENGLAND AND IRELAND.

LONDON UNIVERSITY.

Give an account of the structure of the human eye-ball: compare the structure of the eye with that of the ear; and state what are the principal modifications undergone by the organ of vision in the Animal Kingdom.

What is the meaning of the term "Homology?" On what grounds is it justifiable to assert that two organs or parts are homologous? Illustrate your answer by examples.

What are the chief anatomical and physiological peculiarities of the *Cephalopoda?*

Enumerate the most important distinctive characters of the skeletons of an *Amphioxus*, a lamprey, a cod-fish, and a shark.

What are the most prominent characters of the class *Aves*? Point out in what respects they differ from the *Mammalia* on the one hand, and from the *Reptilia* on the other.

What are the characters of the order *Ruminantia*? Enumerate any genera of ruminants which present exceptional peculiarities.

In what respects do the *Amphibia* (or Batrachian Reptiles) resemble fishes, and differ from other vertebrata?

Give an account of the structure and habits of the *Tæniadæ*, explaining the real nature of the so-called genera *Cysticercus*, *Cœnurus*, and *Echinococcus*.

What variations are presented by the structure of the vertebral column in the class *Pisces*?

In what respects do the *Vertebrata*, *Mollusca*, and *Articulata* differ from, and agree with one another in structure and development?

How is the function of respiration performed in the lobster, the snail, the whelk, and the oyster? State the classes and orders to which each of these animals belong.

What is the nature of the parts denoted by the terms *Vertebra*, *Axis*, *Atlas*, *Pelvis*, *Tarsus*, *Os temporale*, *Os quadratum*?

What are the distinctive characters of the order *Marsupialia*?

Describe the structure and habits of a sponge, and enumerate the orders of the *Protozoa*, giving the distinctive characters of each.

Describe the organization of any *Pulmonate Mollusk.*

Describe and contrast the structure and modes of development of ordinary *Bone*, of *Dentine*, of *Enamel*, and of *Crustacean* and *Molluscan Shell.*

What are the most important and characteristic peculiarities in the organization of an Insect? and how do *Insecta* differ from *Arachnida*, *Myriapoda*, and *Crustacea ?*

A spirally-coiled shell, divided by perforated septa into regular chambers, is placed before you—by what characters would you be guided in deciding whether it belongs to the *Foramenifera*, the *Dibranchiate*, or the *Tetrabranchiate Cephalopoda ?*

Give the characters of the class *Mammalia*, and define its orders.

Give an account of the leading peculiarities of the *Chelonia.*

The term "Shell" is applied to a number of animal parts. Explain the differences between the "shells" of an armadillo, a tortoise, a whelk, a mussel, and a lobster.

Describe the characteristic features of the dentition in *Rodents*, *Ruminants*, *Carnivora.*

Name the classes and orders to which the following animals belong:—oyster, leech, bee, tape-worm.

Give an account of the distinctive characters of the class *Aves*.

Describe the characters of the class *Amphibia*, and the nature of the metamorphoses undergone by certain members of that class.

Enumerate the orders of the class *Insecta*, and describe their distinctive characters.

Describe the general characteristics of the class *Pisces*.

Describe the nature of the respiratory process in Animals, and the principal modes in which that function is performed.

Describe the characters of the following orders:—*Chelonia*, *Marsupialia*, *Coleoptera*.

Refer the specimens A, B, C, D, E, F, before you, to their respective orders, giving the reasons for your determinations.

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Describe the structure and form of the placenta in the cow, hog, dog, and rabbit.

State the principal characteristics of the recent and extinct orders of the *Reptilia*.

Give an idea of the structure of a sea-urchin.

What indigenous orders of mammals belong to South America; what to Australia?

Name the chief families of acanthopterous fishes, giving an example of each.

Describe carefully the nervous collar surrounding the gullet in the higher mollusks.

Describe the general phenomena of development in vertebrata.

State in detail the characteristics of the *Pisces*; name the orders, and give their special characters.

Describe the vascular system of the *Cephalopoda*.

Name the chief families of web-footed birds, noting the characters by which they are best distinguished.

Define precisely those characters which are common to ganoid fishes and selachians,

Describe as minutely as you can the general structure of the *Tunicata*.

Give the names, distinguishing characters, and geographical distribution of the families of *Edentata*.

Mention the principal characters of the *Ganoidei* and *Dipnoi*, together with the names of the most recent genera belonging to these groups.

Describe the peculiarities of the skeleton in birds.

State the dental formula of the skulls on the table.

State the characteristics of the families of the *Edentata*, and of the *Carnivora*.

What characters distinguish *Marsupials* from *Monotremes*, while associating them with other mammals?

Compare the pelvis of the struthious birds with that of other birds and of mammals.

How does respiration take place in the lancelet (*Amphioxus*)?

Describe the circulation in the frog and axolotl.

Give an account of the air sacs in birds.

Describe the structure and metamorphosis of the *Tænia Cœnurus*.

Describe the anatomy of the common star-fish.

Minutely describe the structure of the exo-skeleton of the lobster.

Explain the terms, ornithodelphous, didelphous, and monodelphous.

Give a description of the digestive system in a ruminant.

State the special characteristics of the *Amphibia*.

Give a formula showing the deciduous dentition of the American monkeys.

What orders, families, and species of reptiles are indigenous to Great Britain?

Describe the mouth of a cyclostomatous fish.

In what respects do the *Prosimiæ* (Strepsirrhina) differ from other *Quadrumana?* In what regions of the world do they occur?

State the principal characters of *Lacertilia.*

Describe, as minutely as you can, the structure of a quill-feather in any ordinary bird.

Give an idea of the structure of a sea anemone.

State the chief characteristics of the *Arachnida.*

Describe the nervous system in the *Lamellibranchiata.*

Give the names and characters of the orders of *Arachnida.*

Describe the digestive apparatus in the common star-fish.

Describe the structure of the circulatory system in the higher *Crustaceans.*

What anatomical character clearly distinguishes the higher invertebrate from cœlenterate animals?

Briefly state the names and diagnostic characters of the sub-kingdom *Vermes.*

In what respects do the *Chilognathous* differ from the *Chilopodous Myriopods?*

Contrast the essential characters of *Brachio-podous* with those of *Lamellibranchiate Molluscs.*

Describe the peculiarities of the skeleton in *Chelonia.*

Describe the structure of the shoulder girdle in a bird.

State the characters of the orders of the *Amphibia.*

What common Mammals represent the order *Insectivora* in Britain?

Briefly indicate the most important points of agreement between the classes of birds and reptiles.

Compare the gills of a shark or ray with those of an osseous fish.

Give the names and geographical distribution of the existing genera of the struthious birds.

State the characters of the leading groups of *Artiodactylous Ungulata.*

Give the names and characters of the main divisions of teleostean fishes.

Describe the pecularities in the respiratory organs of birds.

Mention some of the characters by which the poisonous snakes may be distinguished.

Mention the distinctive characters of the elasmobranchiate fishes.

What fishes are known as *Holocephali*, and why are they so called?

Indicate briefly a few points of structure by which the elephant approximates to (all or some) rodents.

Describe the gills of the oyster.

Describe the alimentary canal of the leech, comparing it with that of the earth-worm and of the sea-mouse.

State the principal structural characters of the order *Rodentia.* What genera of rodents are represented in the British Islands?

Describe the structure of a quill feather.

Give the characters of the orders of *Teleostei.*

State the principal characters of the class *Myriopoda.*

Contrast the characters of the *Asteroidea* and *Ophiuroidea.*

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What are the characters of the class *Insecta?* Give examples of its orders.

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Give an account of the principal modifications in the structure of the heart in the different classes of *Vertebrata.*

Describe the principal modifications of the nervous system in invertebrate animals.

To what order of Mammals does the genus *Felis* belong? Give its characters, enumerate its principal species, and state their geographical distribution.

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