Skeleton with Outline of Contour of Body.

1.H., Atlas; 7.H., seventh cervical vertebra; 1.R., first thoracic vertebra; 17.R., seventeenth thoracic vertebra; 1.L., first lumbar vertebra; 6.L., sixth lumbar vertebra; K, sacrum; 1.S., first coccygeal vertebra; 16.S., sixteenth coccygeal vertebra; 6.R., sixth rib; 6.K., costal cartilage; 18.R., last rib; 1, scapula; 1′, cartilage of scapula; 2, spine of scapula; 4, humerus; 5, lateral tuberosity of humerus; 6, deltoid tuberosity; 7, shaft of ulna; 8, olecranon; 9, radius; 10, carpus; 11, accessory carpal bone; 12, metacarpus; 13, digit; 14, sternum; 14″, xiphoid cartilage; 15, ilium; 16, 16′, angles of ilium; 17, ischium; 18, femur (shaft); 19, trochanter major; 20, patella; 21, tibia (shaft); 21′, lateral condyle of tibia; 22, tarsus; 23, fibula; 24, tuber calcis; 25, metatarsus; 26, digit; 27, trochanter minor of femur; 28, trochanter tertius of femur. (Ellenberger-Baum, Anat. für Künstler.)

Principles

of

Veterinary Science

A Text-Book for Use in
Agricultural Schools

By

FREDERICK BROWN HADLEY

Professor of Veterinary Science in the University of Wisconsin
and Veterinarian of the Wisconsin Agricultural
Experiment Station

ILLUSTRATED

No. 5803

SF
747
H13

PREFACE

If veterinary science is to attain its justly deserved place in the agricultural college curriculum, it must be so presented as to bring out the close relationship that should exist between it and the natural and physical sciences now taught.

In this book are incorporated the writer's ideas of the manner in which this object may be accomplished. The text differs from those on veterinary science at present available to agricultural students in that it places greater emphasis upon the important subjects of anatomy and physiology.

No attempt has been made to treat in great detail the various subjects considered, the scope and purpose of the book being to present the more important facts rather than those of highly technical character. The aim has been to select from the immense amount of material available that most suitable for agricultural students.

In Part I the structure and functions of the animal body have been described in such a way that the student may readily use the information in judging animal form, capacity, and productivity, as well as in the problems connected with the feeding and breeding of animals. In Part II the student is shown how to recognize sickness in animals, render first aid treatment, and prevent diseases.

The reason for presenting basic facts relative to the chemistry of the body in the first chapter is that experience shows that students do not appreciate the principles of veterinary science unless they have some knowledge of chemistry. Those who have had only an introductory course in chemistry, or are taking the subject at the same time they are studying veterinary science, should have no difficulty in grasping the facts that it has seemed desirable to include.

This edition is a development of the author's former publication entitled, "The Horse in Health and Disease." The title

7

has been changed to "Principles of Veterinary Science" as the contents have been amplified, better to meet the growing needs of the animal husbandman.

For valuable assistance in the preparation of the manuscript I am greatly indebted to my colleague, Professor A. S. Alexander.

F. B. H.

MADISON, WISCONSIN,
January, 1920.

CONTENTS

PART I

ANATOMY AND PHYSIOLOGY OF ANIMALS

CHAPTER I

CHAPTER II

CHAPTER III

9

CHAPTER IV

CHAPTER V

CHAPTER VI

CHAPTER VII

CHAPTER VIII

CHAPTER IX

PART II

COMMON DISEASES OF ANIMALS

CHAPTER X

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

CHAPTER XV

CHAPTER XVI

CHAPTER XVII

CHAPTER XVIII

CHAPTER XIX

CHAPTER XX

CHAPTER XXI

CHAPTER XXII

CHAPTER XXIII

PRINCIPLES OF VETERINARY SCIENCE

PART I

ANATOMY AND PHYSIOLOGY OF ANIMALS

CHAPTER I

CHARACTERISTICS OF ANIMALS

THE PLACE OF ANIMALS IN NATURE

The **animal kingdom** includes all animal life. It is divided into two subkingdoms: (1) vertebrates, (2) invertebrates. Veterinary science is principally concerned with the former.

The **vertebrates** are distinguished by having a vertebral column or backbone composed of segments known as vertebræ. They are further characterized by never having more than two pairs of limbs, which are always attached to the lower part of the body.

In fetal life the body of the vertebrate is traversed by an unjointed cartilaginous rod, the notocord. In the lower vertebrates this rod persists throughout life, but in the higher it is replaced by the true vertebræ (Fig. 1).

A cross-section of the body of a vertebrate animal shows two cavities, with the vertebral column lying in the partition between the two. The upper cavity is tube-like in form and contains the spinal cord and brain of the central nervous system. The lower cavity contains the alimentary canal, heart, lungs, and other soft organs. Invertebrates have but one cavity which encloses both the nervous system and the soft organs.

Vertebrates are divided into the following five classes: (1) fishes; (2) amphibians; (3) reptiles; (4) birds; (5) mammals.

2   17

The *mammals* form a class, in which we are particularly interested, comprising all large domesticated animals. Mammals are air-breathing, warm-blooded, produce their young alive and nourish them for a variable period on a secretion from the mammary glands, and have appendages of the skin in the form of hairs. They are divided into a great many natural orders. Most farm animals belong to the order of ungulates.

FIG. 1.—*A*, Diagrammatic transverse section through body of a vertebrate: *c.v.*, cavity for visceral organs; *c.n.*, cavity for central nervous organs; *n.*, notocord; *s.n.t.*, sympathetic nerve trunks. *B*, Similar section of invertebrate: *c.v.*, cavity for visceral organs; *n.t.*, nerve trunks.

The *ungulates* are quadrupeds having molar teeth adapted for crushing and grinding food, possessing a complete set of milk teeth, being destitute of a clavicle or collar-bone, never developing five digits, and having the terminal bone of each digit invested by a thick horny covering or hoof. They are divided into two suborders: the perissodactylates, which have an odd number of toes or digits; the artiodactylates, which have an even number.

The *perissodactylates* include only two genera and species: the equus to which the horse belongs; the asinus to which the ass belongs.

The *artiodactylates* include among others the following genera and species: the ruminants or cud-chewing animals, which embrace the ox, sheep, goat, camel, and llama; the omnivora, which embrace the pig.

The *ruminants* remasticate their feed and are cloven hoofed, having two well developed digits on each foot.

The *omnivora* have teeth that are adapted to the mastication of all kinds of food and are provided with four digits on each extremity, two of which are long and two short.

THE CHEMICAL CONSTITUTION OF THE ANIMAL BODY

It is practically impossible to determine the chemical composition of living organic matter because changes are constantly

going on in it. Analyses of dead tissues show that the compounds are very complex, yet not more than twelve separate elements can be demonstrated.   This is a relatively small number when compared to the eighty or more chemical elements known to science. Of these twelve elements only the following six are the most important—carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulphur.   These materials of construction of the body are linked together in different ways to form molecules of enormous size.

Carbon enters the animal body as a constituent of organic compounds, and leaves it either as carbonic acid gas or in simple organic compounds, such as urea.   This element makes up a large part of the animal body.

Hydrogen occurs in nature in such combinations as water and ammonia.   It is in these forms that it is taken up by plants and converted into a constituent of organic compounds.   Hydrogen is given off by the body in the same forms as acquired, that is, as water and in combination with nitrogen to form ammonia, and as a constituent of organic compounds.

Oxygen is the only element entering the body in a free state. It is essential to the animal, for life cannot exist for any length of time without it.

Nitrogen enters the body in large amounts in protein combinations, and leaves it as urea and other products which easily yield ammonia.

Phosphorus, although present in the smallest quantity of any of the six principal elements, is one of the most important that enters into the formation of the body.   It never occurs in the free state but is present in a greater diversity of compounds and plays a more vital function than any other element.   It enters the body as a constituent of vegetable and animal foods, and is excreted largely in the urine, although traces are found in the feces.   Forbes of the Ohio Experiment Station in speaking of phosphorus said: "Structurally, it is important as a constituent of every cell nucleus and so of all cellular structures; it is also prominent in the skeleton, in milk, in sexual elements, glandular tissue, and the nervous system.   Functionally, it is involved in all cell multiplication, in the activation and control of enzyme actions, in the maintenance of neutrality in the organism, in the conduct of nerve stimuli, and through its relation to osmotic pressure, surface tension, and imbibition of water by colloids it

has to do with the movement of liquids, with the maintenance of proper liquid contents of the tissues, with cell movements, and with absorption and secretion."

Sulphur is present in small amounts in all animal bodies.   It is taken in as a part of the protein molecule, and is largely excreted in the urine in the form of sulphates.

It is customary to divide the constituents of the animal body into (I) inorganic and (II) organic compounds.

I. **Inorganic compounds** are water and mineral substances. The former is determined by evaporating the tissues to dryness, the latter by burning them and recovering the ash.

(1) **Water** comprises about 56 per cent of the body weight. For the most part it is combined with the other constituents, although a considerable quantity is found as water in the contents of the digestive organs.   The muscles of food-producing animals yield almost constantly 78–79 per cent of water.   The bodies of lean animals always contain more water in proportion to their weights than do those of fat animals.   A young animal has a larger percentage than a mature animal.   The importance of water is seen by depriving an animal of all water, when death will occur quicker than if solid food were withheld and water given.

(2) **Mineral substances** make up about 5 per cent of the body weight.   They largely consist of the salts of sodium, potassium, calcium, magnesium, and iron, in the form of chlorides, sulphates, phosphates, and carbonates.   Of these, calcium phosphate, the principle constituent of bones, predominates.   Approximately 80 per cent of the total ash compounds of fat animals are found in the bones.   An animal deprived of all mineral-containing matter will live but a short time.   This shows the great importance of these substances.

II. **Organic compounds** comprise the balance or about 39 per cent of the weight of the body.   They are characterized by always containing carbon.   They may be subdivided for study into nitrogenous and non-nitrogenous substances.

(1) The **nitrogenous substances** include all the organic compounds having nitrogen in their molecules.   They have various characteristics and properties.   For a complete discussion of these substances references should be made to textbooks on organic chemistry.   The most important of this group of highly complex compounds are the proteins.

Proteins comprise a large part of the solid matter of the muscles, tendons, blood, skin, etc. The most plentiful body protein is myosin, which is found in the muscles. Proteins are the substances used by the animal for growth. They are mostly colloidal in character, only a very few having been obtained in crystalline form, so do not diffuse through an animal membrane. Chemists have not been able to synthetize any but the very simple proteins. This undoubtedly is because the protein molecule is of such great size and complextiy that during life it is capable of a wide variety of combinations and readjustments. Carbonic acid, water, urea, and uric acid are the end-products of protein decomposition, but many intermediate substances, such as the cleavage products, glycin and leucin, occur during the breaking-down process.

Albuminoids are closely allied to the proteins, but differ from them by being insoluble in all neutral solvents. The best-known members of the group are collagen, gelatin, chondrin, elastin, and keratin. *Collagen* is the intercellular substance of connective tissues, and under the name of *ossein* forms a large part of the organic basis of bones. By boiling with water, collagen is readily converted into *gelatin*, the familiar jelly-like substance used so generally. *Chondrin* is obtained from the ground substance of hyaline cartilage. *Elastin* is obtained from the fibers of elastic tissues. *Keratin* is the characteristic constituent of epidermal structures, such as hair, nails, feathers, and horn. It contains from 3 to 5 per cent of sulphur, a large portion of which is easily set free as hydrogen sulphid, and will combine with other substances, particularly lead solutions, to form the black sulphid of lead, which is used for hair dyes. When these keratin-containing structures are burning, their sulphur is liberated and produces the characteristic disagreeable odor.

Enzymes are complex organic compounds capable of producing, by catalytic action, the transformation of some other compound. They are peculiar in that they remain unchanged though used over and over again, act best at body temperature, are inhibited by cold, are the product of glands, cannot be isolated. The specific reactions of the various enzymes will be mentioned when the organs manufacturing them are considered. Well known enzymes are the ptyalin of saliva and the pepsin of gastric juice.

Pigments of the body are nitrogenous in nature. They are found in the body and milk fats, the skin, hair, horn, eye, and pathologically in the melanotic tumors so common in white and gray horses. Chemically the natural yellow pigments of the animal body are similar to and derived from the yellow vegetable pigments found accompanying chlorophyl in all green plants.

Nitrogenous fats are represented by lecithin, a complex compound containing a relatively large amount of phosphorus.

Amino-acids are the simple nitrogenous bodies, derived from the proteins of digested foods, that are found in the circulating blood and tissue fluids. They are available for use by the animal to build up its protoplasm.

Urea and **uric acid** belong to a group of nitrogenous waste compounds found in the excreta of the body.

(2) The **non-nitrogenous substances** are fats and various carbohydrates. It is evident that no nitrogen is present in their molecules.

Fats contain the elements carbon, hydrogen, and oxygen. The latter is present in very small percentage. Neither hydrogen nor oxygen is present in the proportion to form water. The principal animal fats are stearin, palmitin, and olein. They are derived from both animal and vegetable fats consumed as food. Chemically, fats are esters of glycerol and the fatty acids.

Carbohydrates contain the same elements as fats but in simpler combinations. They occur chiefly as monosaccharids, disaccharids, and polysaccharids. A member of the first group found in the animal body is dextrose. Lactose, or milk sugar as it is commonly called, is a constituent of milk and belongs to the group of disaccharids. The more highly organized polysaccharids of the body are represented by glycogen, or animal starch. It is found in the liver, muscles, and other tissues and occurs in large quantities in all fetal tissues. Carbohydrates are used by the body to furnish energy.

THE CELLS OF THE ANIMAL BODY

In a well planned system of education the simplest subjects are taken up first to prepare the student for the more complex that are to follow. This plan will be followed in our study of the structure of the animal body, and will start with the smallest structural unit of life—the cell.

It is commonly known that all living bodies develop from one relatively simple *cell*. In a perfectly orderly way, nature has provided for the development of groups of cells from the parent cell, to form, first, the *tissues*, which in turn form the *organs*, and *systems*. Eventually the *animal body*, that highly complex structure composed of countless millions of these microscopic elements, is formed.

While all cells are of a common descent, some have undergone great modification as to form and function. This specialization is seen in the grouping of cells that have work of a similar nature to perform. For instance, the fat-cells are very passive, and as they perform the function of storing reserve food material they are placed in those parts where least interference will be had with the more active parts. The cells lining the air-passages are very active and their cilia are in continual motion. Other cells, such as certain kinds found in the blood, are still different and possess the power to move from place to place.

By developing along one definite line, cells lose their primitive power to receive and utilize all kinds of food. Nature, therefore, has provided certain standard forms of food for their sustenance. However, a cell can feed only on that with which it comes in contact. Food is supplied to each cell and waste is removed by the blood and tissue fluids. The exact manner by which this exchange is made possible will be discussed in later chapters. It is evident that no cell or group of cells is sufficient unto itself, but relies on the normal interchanges, which appear to be of a chemical nature, that take place with other cells.

Although a detailed study of cell structure can be accomplished only with the aid of a microscope and is therefore beyond the scope of this book, it is necessary, before considering larger structural parts of the body, to note the general characteristics of *typical animal cells* (Fig. 2). Each possesses a cell body surrounded by a cell wall, a cell nucleus, a nucleolus, and one or more centrosomes.

The *cell body* or *protoplasm* is the basis of the cell and life processes and will be described fully in the succeeding paragraphs. The *cell wall* or *capsule* confines the other parts; it is not so nearly complete in the animal as in the plant; furthermore, in the former it is composed of protein substances, while in the latter it is of carbohydrate material. The *cell nucleus* or

germ center is the essential and active part in reproduction. The *cell nucleolus* is a minute rounded body contained in the nucleus. The *cell centrosome* is a highly refractive body with many fine radiating fibers and has to do with cell division.
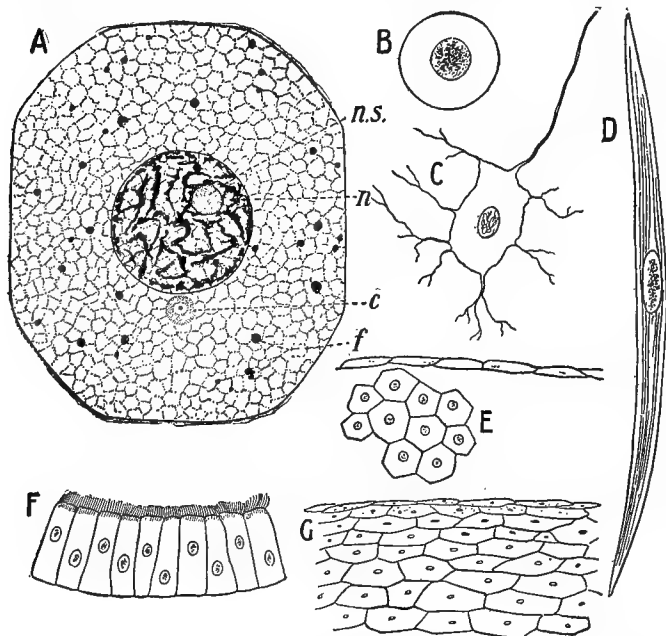
Fig. 2.—Different types of cells composing the body. *A*, Typical cell showing: *c*, centrosome; *f*, food granules in the protoplasm; *n*, nucleus; *n.s.*, nucleolus; *B*, complete cell; *C*, nerve cell with axon and dendrites; *D*, involuntary muscle-fiber; *E*, endothelial cells; *F*, ciliated epithelial cells from trachea; *G*, stratified squamous epithelium from the skin. (Jordan and Kellogg, Evolution and Animal Life.)

Protoplasm is a transparent, viscid substance to the sight and touch. On close examination it is found to be a complex mass of organic material held together by a very delicate meshwork of fibers. In plants and animals protoplasm is essentially the same. It contains about 80 per cent of water, which is in a state of chemical combination.

Three well-known physical forces operate in living protoplasm. They have been described by Wentworth as follows: First,

capillarity, or the power that makes water stand higher at the edges of a glass than in the center, exerts a profound influence on the nature of the chemical reactions that take place.   Second, *surface tension,* the force that permits water to "heap up" slightly above the top of a glass so that it is more than level full, or that lets a dry needle float on the surface of water, keeps the compounds of different density separate, so that each may be almost as distinct from the other as though it occupied a different test-tube.   Third, *osmosis,* the force that permits liquids of different densities to interchange through bladder membranes, allows some interchange of the products of one reaction through the different compounds of the protoplasm.

Living matter (protoplasm) is essentially something that performs a function.   It does not remain in a state of equilibrium, but is continually either storing or liberating energy under fixed conditions and may be thought of as a mechanism in which chemical processes of a special nature are continuously going on. These processes are called *metabolism* and are of two kinds, viz.: anabolism and katabolism.   *Anabolism,* or the building-up process, is characteristic of plants.   In the presence of sunlight the green leaf takes carbonic acid gas from the air, and water with mineral elements from the soil, and evolves a more complex substance from them that possesses a high degree of energy.   Our animals benefit from this and find here materials to support their breaking-down process, or *katabolism.*   The energy thus stored by the plant is released to the animal for his use.   The combination of these metabolic processes is one of the safest methods of distinguishing simple living matter from non-living.

From a physiologic standpoint we may group processes that are constantly going on in living matter under the following ten headings:

1. **Ingestion** is the power of taking food particles into the protoplasm.   In the simplest cases it probably represents merely the flowing of the protoplasm around the food.

2. **Secretion** is the response of the protoplasm to these food particles.   It corresponds in a primitive way to the production of the saliva in the mouth and the gastric juice in the stomach. It is simply the production of certain juices, activators, enzymes, or hormones, as they are variously called, that have a chemical action on the food.   Each kind of body cell has its own particu-

lar enzymes, some of which are extracellular, while others are intracellular.

3. **Digestion** is the direct action of these secretions on the food particles. Only food that is digestible by its enzymes can be used by the cell. It so changes the chemical composition of the food that it becomes available for energy, or for the building up of the protoplasm. It is possible that these two uses are similar.

4. **Assimilation** is the incorporation of the digested food particles into the protoplasm. In simple forms it is the equivalent of anabolism.

5. **Katabolism** is the process of liberating the energy stored up in the protoplasm. It may be termed a tearing-down function, in the sense that complex chemical compounds are torn down to yield their quota of energy. Complementary to this is the elimination or excretion of the waste-products of energy production and also those of digestion and assimilation.

6. **Irritability** is the sensitiveness that the protoplasm shows to stimulation by outside objects. It is the foundation of the forces that have become so highly developed and specialized in the muscle- and nerve-cells. This response to a stimulus is more highly developed in the mammalia than in reptiles, and in the latter than in fishes.

7. **Motility,** or the power of movement, is one of the chief means of recognizing living matter. Its simplest manifestation, a flowing of the protoplasm due to changes in surface tension, is represented in the white cells of the blood that act as scavengers and destroy disease-producing organisms. Contractility, a function of muscle-cells, is an example of modified motility.

8. **Growth** is one of the essentials that has come to have an extreme economic value. It needs little discussion because all can witness it, and further, as the scientist is but little nearer its fundamentals than the layman. It has been said to represent the excess of anabolism over katabolism. Living things grow by absorbing new material from without and transforming it into substances of their own bodies. Growth takes place only through a certain period, being rapid during youth, about stationary at maturity, and negative during old age. In fact, there is usually a gradual decay and wasting away during old age, finally leading to a complete cessation of the vital processes. This is spoken of as senile degeneration. For each species there is a limit to

the period of growth: most small animals develop completely in a year; horses take four to five years; man approximately twenty-one years. The average height of man is 5 feet, 8 inches. The average weight of the horse is between 1000 and 1100 pounds. Giants and dwarfs are always abnormal productions and represent pathologic changes. These abnormalities are not transmitted to the offspring. The feeder of animals should aim to get the maximum growth each day for, as has been stated, growth ceases after a certain age.

9. **Reproduction** is probably the most remarkable and interesting of all the processes of living matter. It represents the power to produce new but similar individuals. Detailed consideration of this process will be postponed until the reproductive organs of the body have been studied, when it can be more easily understood.

10. **Response to environment** is the power that induces the production of substances that help to neutralize disease and to repair wounds, and adapts the body to its physical surroundings.

The possession of these processes make cells highly efficient energy-transformers, and admirably adapted to the important work that they perform.

Besides the cells, the body is composed of a framework of intercellular substance. If all the cells were removed there would still remain connected meshes like basket work that would represent the whole form of the body in all its parts and much of its solidity would remain. This intercellular substance, which varies in character in different places, comprises much of the skeleton and the bulkier part of all connective tissues which permeate all tissues and organs.

THE TISSUES OF THE ANIMAL BODY

A tissue is a collection of more or less similar cells possessing functions somewhat alike. Body tissues are divided into the vegetative tissues, which support, bind together, protect, and nourish; and the master tissues, which control the body.

A. The **vegetative tissues** may be separated into (I) epithelial tissues and (II) connective tissues.

I. **Epithelial tissues** consist of large numbers of cells and a very small amount of intercellular or cementing substance, so they fit together very closely. They develop from the

epiblast and hypoblast of the embryo and are found on or near surfaces of the body.   All are capable of rapid replacement when injured or destroyed.   This makes them well fitted to cover surfaces exposed to injury.

There are four kinds of epithelial tissue, namely: (1) squamous epithelium; (2) columnar epithelium; (3) secreting epithelium; (4) ciliated epithelium.

1. *Squamous epithelium* is primarily a protective tissue and is composed of flat, scale-like cells.   Its cells may be in single layers, like the cells lining the air sacs of the lungs; or stratified and composed of several layers piled one upon the other as are the cells of the skin, hair, horns, and hoofs (see Fig. 2).   The upper layers are farthest from the nutrition supply, and so lose their sensitiveness and become hard and act as good protective agents.   Poisons cannot readily pass through, and chemicals do not act easily on, intact epithelium.   Its function is chiefly to protect the sensitive structures beneath, like the "quick" under the hoofs.

2. *Columnar epithelium* derives its name from the shape and arrangement of its cells, which are longer than they are broad. It is found lining the stomach and intestines.   The chief function is to take up matter digested by these organs and to pass it on to the blood.

3. *Secreting epithelium*, as the name indicates, has to do with the secretions of the body, and is found composing the various secretory glands, all of which are epithelial outgrowths.   The simplest form of gland is the tubular (see Fig. 28).   Branched and compound glands are more complex.   Depending upon the substances produced, secreting epithelium may be:

(*a*) Mucin-secreting epithelium, which is the variety found wherever mucous membranes are located, that is, in all passages which communicate either directly or indirectly with the outer air.   It secretes a slimy substance known as mucin for lubricating the mouth, stomach, intestines, and other organs.   Mucin is of great importance in the animal economy.   When precipitated and freed from water it is white and amorphous.   On the addition of water it swells and forms a transparent glairy mass.   Its function is to act as a lubricant.

(*b*) Zymin-secreting epithelium, which forms the various juices in the mouth, stomach, and bowels that act upon and digest the food.   The activity of the secretions is due to the

presence of enzymes, zymins, or hormones.   During the activity incidental to digestion these cells give off or secrete large quantities of enzymes.   When this process ceases, the cells, now in the so-called resting stage, are storing up their product for future use.   Certain granules, which disappear with glandular activity, are responsible for the action of the secretion.

(c) Excreting epithelium, which has the power to pass substances out of the body that are of no further use.   Example; are the epithelium of the kidneys, sweat glands, and mammary glands.   It not only is capable of taking up material from the blood and passing it out (urine), but may even alter it greatly before passing it out (milk).

4. *Ciliated epithelium*, which is characterized by little hairlike processes called cilia (see Fig. 2).   These cilia vary in length, depending upon their location.   In the living state they are in constant motion like a grain field waving in the wind, each cilium is first bent down in one direction and then assumes the erect position.   All cilia of an organ work harmoniously in the same direction, the motion begins at one end of the surface and ends at the other.   The function of this tissue is to work substances from the inner parts of the body outward.   It is found lining the air passages and in the female genital tract, where it aids the passage of the ovum from the ovary to the womb.

II. **Connective tissues** develop from the mesoblast of the embryo and are found in all parts of the body.   They are primarily to support and hold more highly specialized, active tissues in position.   They are composed of but few cells and a large amount of intercellular or cementing substance, which, though outside the cells, has been derived from them.   The activity of the constituent cells is confined chiefly to producing and maintaining the tissues and to restoring them when injured.   After injury to the physiologically more active tissues with less regenerative power, connective tissues may be produced to take their place. Examples are seen in cirrhosis of the liver, where the active gland cells are to some extent replaced with fibrous tissue, and in scars. Connective tissues may be divided into three classes: fibrous tissue, cartilaginous tissue, and bony tissue.

1. *Fibrous tissue* is composed for the most part of bundles of minute fibers.   It may be differentiated as follows:

(a) White fibrous tissue, which is silvery white in appearance,

is found as a connecting tissue framework in various parts of the body. Tendons and ligaments are composed almost entirely of it. It is not extensile.

(b) Yellow elastic tissue, which is firmer than the white fibrous, is much more extensile. It forms the ligamentum nuchæ, that broad and elastic support stretching from the head to the withers. The walls of the blood-vessels and the air tubes of the lungs also contain yellow elastic fibers.

(c) Fatty, or adipose tissue, which serves as a storehouse for excess fat, occurs where the fibrous connective tissue is arranged loosely so that spaces are formed between the bundles of fibers. Little droplets of oil, that finally coalesce to form a single globule, collect in the cells and distend them so that the protoplasm and nucleus appear to form a sort of cell capsule. Fat cells, therefore, may be regarded as modified connective-tissue cells. Fatty tissue is found interwoven or intermingled with the muscles and the vital organs and under the skin where it forms an effective covering or insulator for the body to prevent rapid radiation of heat. On this account, a fat animal needs less food than a lean one to maintain itself. The amount of fatty tissue in the body varies with the age and condition of the animal, but is more pronounced in later life. Cold weather induces fat production, as is seen by the fact that animals increase in weight during the winter. Fat from the carcass of the ox is known as beef tallow or suet; that from the hog as lard; and that from the sheep as mutton tallow.

2. *Cartilaginous tissue* is glass-like in appearance, translucent, homogeneous, tough, and highly elastic, so is placed where these qualities are needed. It cuts like cheese and is commonly named "gristle." Cartilage cells are peculiar in character and relatively few in number. All cartilage in the body is surrounded by a membrane known as the perichondrium, a fibrous tissue which carries blood-vessels to nourish the cartilage cells.

There are two kinds of cartilaginous tissue: (a) Hyaline cartilage is a bluish-white color and covers the ends of long bones; (b) fibrous cartilage is white and found between vertebræ. In the embryo most bones are represented by cartilage; later this is usually replaced by bone tissue. The rings of the trachea, the epiglottis, and the covering at the ends of long bones are examples of cartilaginous tissue which persists in the mature animal.

3. *Bony tissue*, like other tissues, is composed of organic and

inorganic matter, but differs from them in containing more of the mineral elements. The organic matter constitutes about one-third the total amount in mature bones, and when freed from the inorganic substances is known as ossein, a form of gelatin. This may be demonstrated by soaking a fresh bone in weak hydrochloric acid to dissolve out the inorganic matter (decalcification). All hardening constituents are lost and while the original shape of the bone is retained, the mass is soft and flexible like India rubber. The organic matter gives bone its elasticity and tenacity. The inorganic or mineral matter constitutes the other two-thirds and is in the form of:

Calcium phosphate...	57.35 per cent
Calcium carbonate...	3.85 per cent
Magnesium phosphate	2.05 per cent
Sodium salts........	3.45 per cent
	66.70

The inorganic matter renders bone hard and dense. This combination of animal and mineral substances gives solidity to the bones, yet elasticity enough to prevent fracture under ordinary circumstances. It is very difficult to break a green bone on this account.

On sectioning a bone there are revealed two varieties of bone texture: the outer or compact tissue, and the inner, cancellated or spongy tissue (Fig. 3).
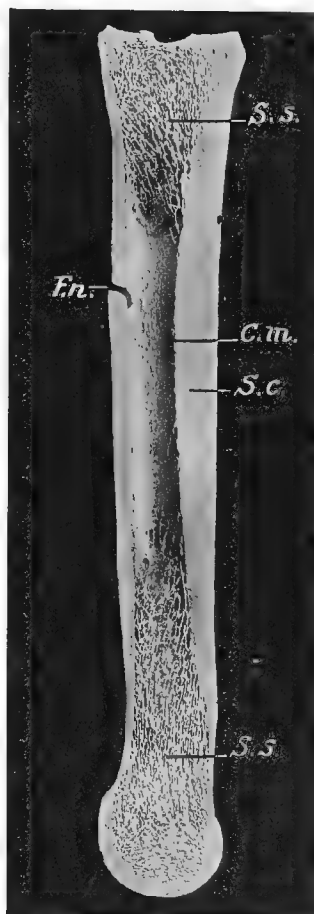
FIG. 3.—Sagittal section of right large metatarsal bone of horse: *S.c.*, Compact substance; *S.s.*, spongy substance; *C.m.*, medullary cavity; *F.n.*, nutrient foramen. Note the greater thickness of the compact substance of the anterior part of the shaft. (Sisson, Anatomy of Domestic Animals.)

(*a*) Compact bony tissue is dense, close grained, and varies in thickness. In long bones it occurs in greatest amount in the shaft, the center of which is almost exclusively composed of it. Toward the ends of long bones it gradually diminishes in thickness until at the extremities it forms only a shell-like covering. On account of its resistance it is found in abundance wherever great strain is placed on a bone. In the cannon bone it is thick in the center, but thicker in front than behind, and on the inside than outside, in correspondence with the lines along which the greatest weight of the body falls.

A close examination of the structure of the compact tissue shows a series of extremely thin plates or bars of bony substance
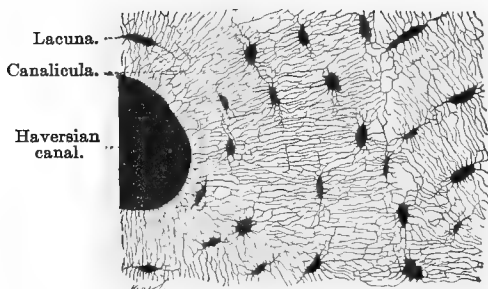
FIG. 4.—Transverse section from the shaft of a long bone, showing microscopic appearance of compact bone tissue. (Böhm and Davidoff.)

that are generally arranged in rings around small channels, known as Haversian canals, in which blood-vessels pass in the direction of the long axis of the bone (Fig. 4). Between these plates are spaces called lacunæ that communicate with each other and with the Haversian canal by means of numerous extremely small canals or canaliculi. Through these connecting channels nutrient fluids find their way to all parts of the bone.

(*b*) Cancellated bony tissue is porous in appearance and composed of great numbers of little bony plates and spicules surrounding spaces that are filled with red marrow in the living animal. There is little spongy tissue in the centers of the shafts of long bones, but at the extremities it increases in amount and forms nearly the entire mass. It is less resistant than compact bony tissue, but is useful in giving the bones surface without adding

to the weight, *e.g.*, ends of bones where they articulate to form joints.

The skeleton of the primitive embryo consists of fibrous and cartilaginous tissues.   These are changed to bone by a gradual deposition of earthy salts.   The process is termed ossification, and is effected by bone-producing cells, called osteoblasts.   One or more centers of ossification that are quite definite in most bones indicate where true bone formation begins.   The division or epiphyseal line between the different areas may be clearly seen in the bones of the limbs until the animal is several years old (see Fig. 75).

Overlying the compact tissue of a fresh bone is found a thin, tough, unelastic membrane called the *periosteum*.   It is present on all parts of the bone except the articular surfaces, where cartilage is found.   Blood-vessels and nerves for the bone run in the periosteum.   When it is destroyed, that part of the bone beneath it is likely to die as the bone-building cells are contained in the periosteum.

Bone-marrow is the soft material found in the center of bones. In color it is either red or white.   The red marrow produces certain kinds of red blood-cells.   It is found in the shafts of long bones and in flat bones.   In the young animal it is relatively much greater in amount than in the old animal.   Yellow marrow is about 96 per cent fat and appears to have no particular function. It replaces part of the red marrow in the bones of mature animals.

B. The **master tissues** comprise (I) the muscles and (II) the nerves.   They will be described in special chapters, as they are of sufficient importance to deserve more detailed consideration than can be given here.

THE ORGANS AND SYSTEMS OF THE ANIMAL BODY

Organs are well-defined parts, such as the heart, liver, and brain, that perform a particular function.   They are always composed of several kinds of tissues.   Groups of organs that have work of a common nature to perform are known as systems. There are seven clearly defined systems in all mammals:

(1) Skeletal system, or organs of support.
(2) Muscular system, or organs of motion.
(3) Digestive system, or organs of digestion.

3

(4) Respiratory system, or organs of respiration.

(5) Urogenital system, or organs of urination and reproduction.

(6) Circulatory system, or organs of circulation.

(7) Nervous system, or organs of innervation.

Descriptive terms are employed to indicate the exact position and direction of parts and organs of the body. These terms refer to the animal in the ordinary standing position. The surface directed toward the ground is termed *inferior* or *ventral*, and the opposite surface is *superior* or *dorsal*. An imaginary median plane divides the body into halves. A structure or surface which is nearer than another to the median plane is *internal* to it; and an object or surface which is further than another from the median plane is *external* or *lateral* to it. The head end of the body is termed *anterior*, *cephalic*, or *cranial;* and the tail end, *posterior* or *caudal*. *Proximal* and *distal* represent distances from the vertebral column.

THE SKELETAL SYSTEM

THE SKELETON OF THE HORSE [1]

The *skeleton* may be divided for description into an axial portion, consisting of the bones of the head and trunk, and an appendicular portion, comprising the bones of the limbs (Frontis-piece). The number of bones in the skeleton of an animal varies with the age, owing to fusion of bones which are separate in the young. There are 207 bones in the skeleton of the adult horse. When dried the bones constitute from 7 to 8.5 per cent of the body weight.

The bones of vertebrates are embedded in the soft structures of the body, so are termed the **endoskeleton.** Many invertebrates have a skeleton placed outside the softer parts, as in the case of the lobster's shell; such an arrangement is called an **exoskeleton.** Occasionally a bone is found embedded in a soft organ and does not articulate with the general skeleton; it belongs to the so-called **splanchnic skeleton.** The *os cordis* in the ox's heart, *os penis* of the dog, and *os rostri* in the snout of the hog are examples of bones belonging to the splanchnic skeleton.

It is customary to classify the bones according to their shape. The names, locations, and functions of the classes follow.

Long bones have a marrow cavity and consist of a shaft and two extremities. They are found exclusively in the limbs where they serve as columns of support and act as levers, *e.g.*, femur or thigh bone.

Flat bones are composed of two thin layers of compact substance with a varying amount of cancellated substance between. They serve to protect organs and to afford extensive surface for the attachment of muscles, *e.g.*, scapula or shoulder-blade.

Short bones are cubical in form and occur chiefly in compound joints where they aid in facilitating movement, *e.g.*, the hock.

Irregular bones are all single and lie along the median plane, *e.g.*, vertebræ.

General terms used in the description of bones are defined as follows:

[1] See Appendix for classified list of bones of the skeleton.

35

A *process* is a projection or elevation.

A *tuberosity* is a rough or obtuse process.

A *tubercle* is a small and usually more or less pointed process.

A *condyle* is a rounded and somewhat elongated process.

A *fossa* is an irregular ditch-like depression.

A *foramen* is an aperature for the passage of vessels and nerves.

A *facet* is a flat articular surface.
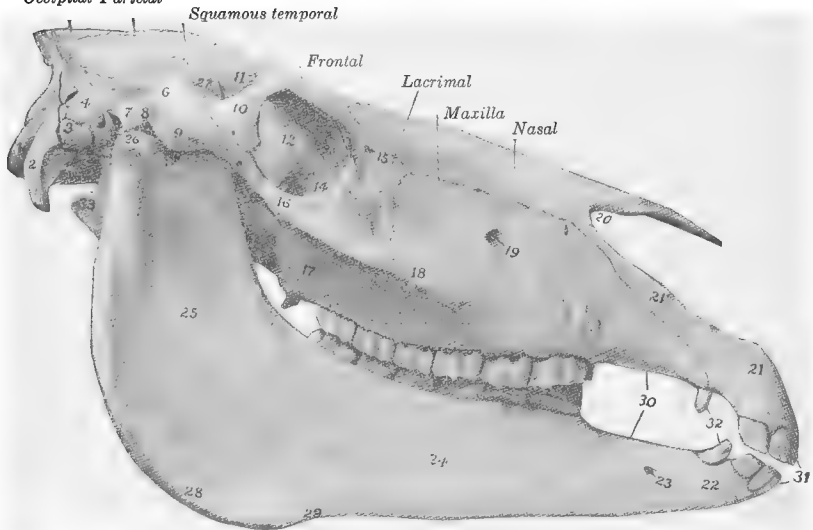
Fig. 5.—Skull of the horse (right view): 1, 2, Occipital bone; 3, 4, 5, 6, 7, 8, 9, processes of temporal bone; 10, 11, 12, parts of frontal bone; 13, 14, 15, lacrimal bone; 16, malar bone; 17, tuberosity of maxilla; 18, facial crest; 19, infra-orbital foramen; 20, nasomaxillary notch; 21, body of premaxilla; 21', nasal process of same; 22, 23, 24, 25, 26, 27, 28, 29, mandible; 30, interdental space; 31, incisor teeth; 32, canine teeth; 33, hyoid bone.   (Sisson, Anatomy of Domestic Animals.)

BONES OF THE AXIAL SKELETON

The *axial skeleton* consists of the head and trunk.

A. The **head** is composed of the bones that form the skull and the hyoid bone.

The **skull** is divided into the cranium, which encloses the brain and the essential organs of hearing and the face, which includes all the other bones of the head except the hyoid (Fig. 5).   Most

of the bones of the skull are flat. The spaces or cavities between these bones are known as *air-sinuses*. They add to the volume of the skull without increasing its weight.

The *bones of the cranium* are the occipital, sphenoid, ethmoid, interparietal, parietal, frontal, and temporal. The first four are single, the others paired. As compared with the body, the cranium of the horse is remarkable for its small size.

The *bones of the face* are important for some of them carry the teeth. They are the maxilla, premaxilla, palatine, pterygoid, nasal, lacrimal, malar, superior and inferior turbinals, vomer, and mandible. The last two are single, the others paired. They form the walls of the oral and nasal cavities. The shape of the nose and the coarseness or fineness of the head are determined by these bones.

The **maxillæ** are the principal bones of the upper jaw and carry the upper molar teeth. They are situated on the lateral aspects of the face. Each presents two surfaces. The external surface is convex, especially in the young animal. The prominent ridge noted on this surface is the facial crest. A little above and in front of this crest is the infra-orbital foramen. The internal surface is concave, smooth, and forms part of the wall of the nasal cavity. A ridge gives attachment to the inferior turbinated bone, above which is the lacrimal canal. Springing medially from the lower part is the palatine process, which forms a large portion of the hard palate and meets its fellow at the median plane. The inferior border has six alveoli for the upper molar teeth.

The **premaxillæ** are situated in front of the maxillæ. They are strongly developed anteriorly. Each has three alveoli for incisor teeth. The palatine processes project backward to form the anterior part of the roof of the mouth.

The **palatine bones** are small and may be considered as extensions to the hard palate.

The **pterygoid bones** are thin, strap-like attachments to the palatine bones.

The **nasal bones** form most of the roof of the nasal cavity. The dorsal surface is convex, the ventral concave and provides attachment for the superior turbinated bone. The anterior extremity is pointed, thin, and free.

The **lacrimal bones** are situated in front of the eyes.

The **malar bones** are situated below the lacrimal bones and correspond to the cheek bones of man.

The **turbinated bones**, four in number, two on each side, divide the nasal cavity into three passages. The bones are very delicate and are covered in the living animal with mucous membrane. The anterior extremity of each bone is prolonged to the nostril by a plate of cartilage.

The **vomer** is a single bone placed in the median plane. It is grooved for the reception of the septal cartilage of the nose.

The **mandible,** or **lower jaw,** is the largest bone of the face. It is composed of a body and two branches. The body is the anterior part, which lodges six incisor teeth. Behind these, in the male on each side, is an alveolus for a canine tooth. The branches diverge backward from the body to form the submaxillary space. Each branch has a horizontal and a vertical part and presents two surfaces, two borders, and two extremities. Both surfaces of the horizontal part are slightly convex and smooth. The superior border has six alveoli for the lower molar teeth; the inferior border is thick and rounded in the young animal, but becomes thin and sharp in the old. The vertical part is wide and thin with external and internal surfaces that are concave and rough to lodge the powerful muscles of mastication. The anterior extremity joins the body, while the posterior presents an articular condyle for the temporal bone. A thin, flat process projects upward from the front of this articular surface.

The **hyoid bone** is situated between the vertical parts of the mandible. It supports the root of the tongue, the pharynx, and the larynx.

B. The **trunk** is composed of the vertebral column and the thorax.

The **vertebral column** is made up of five groups of vertebræ, designated cervical, thoracic, lumbar, sacral, and coccygeal in the order of their occurrence. Each group has a typical number of segments as shown in the following formula:

$$C_7 T_{18} L_6 S_5 Cy_{15-21}.$$
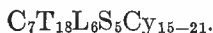
Individual vertebra in each group closely resemble each other. All the vertebræ are constructed on a common plan, so a description of a typical member will serve as a basis, and any marked deviation from this plan will be noted afterward.

A *typical vertebra* presents the following features: A *body*, which is a cylindrical mass of bone upon which the other parts are built up. The upper surface of the body is flattened and forms the floor of the spinal canal. The anterior extremity presents a convex head to articulate with the posterior concave surface of the preceding vertebra. Between each two vertebræ there is a cartilaginous disk which binds the bones firmly together. An *arch*, which is built up on the upper surface of the body and completes the canal for the spinal cord. The *processes*, which are of three varieties: (1) articular processes, which project forward and backward from the arch; (2) transverse processes, usually two in number, which project outward from the lower part of the arch; (3) a spinous process, which is single and projects upward from the arch.

The *cervical vertebræ* form the skeleton of the neck. There are seven bones in this group. The first two are modified so as to allow the skull to move more freely. ' A typical member of this group has an extremely long body with a large, strong arch and spinal canal. The articular processes are well developed. The transverse processes are wide and plate-like. Each spinous process is small. The first cervical vertebra is called the *atlas* and has no body, instead it is modified in the form of a ring. On each side of the anterior edge of the ring is a deep articular cavity for a condyle of the occipital bone of the skull. The posterior edge articulates with the axis. The *axis*, or second cervical vertebra, has a very long body. The anterior extremity presents centrally a projection called the odontoid process. The posterior extremity has the usual concave articular surface. The spine is prominent, wide, and thick.

The *thoracic*, or *dorsal vertebræ*, are usually eighteen in number, in the horse, sometimes nineteen, rarely seventeen. The body is short and presents laterally two concave facets for articulation with the heads of the ribs. The arch is small. The articular processes are slightly developed; the transverse processes are short and thick, and each has a facet for articulation with the tubercle of a rib; the spinous process is long, and together they determine the contour of the back and withers (see frontispiece).

The *lumbar vertebræ* comprise the six bones in the region of the loins. The bodies are longer than those of the dorsal region.

The transverse processes are wide, flat plates, resembling an undeveloped rib.

The *sacrum*, or *croup*, is composed of five vertebral segments which are fused so as to form a single bone.   It is triangular in form and is wedged between the ilia.   Two surfaces, two borders, a base, and an apex are presented for description.   The dorsal surface has a crest composed of the partially fused spinous processes.   The ventral surface is slightly concave from before backward.   The borders are formed by the fusion of the transverse processes and present in front a facet for the articular surface of the ilium.   The base is represented by the anterior surface of the first sacral vertebra.   The apex is small and articulates with the first coccygeal vertebra.

The *coccygeal vertebræ* comprise all of the movable vertebræ behind the sacrum.   They vary in number, depending on the development of the tail, and gradually diminish in size, so that the spinal canal finally becomes a mere groove on the upper surface of the bones.

The **thorax,** or **chest,** is made up of the ribs and the sternum. It is much compressed laterally in its anterior part, but widens behind.

The **ribs** number eighteen pairs, and are connected at one extremity with the thoracic vertebræ and at the other with the sternum.   They are divided into eight pairs of true ribs and ten pairs of false ribs.   The *true ribs* articulate directly by means of their cartilages with the sternum, while the *false ribs* articulate by cartilaginous extensions.   A *typical rib* is an elongated flat bone with two surfaces and two extremities.   The external surface is convex and roughened; the internal concave and smooth.   The dorsal end has three distinct parts, the head, neck, and tubercle.   The head is convex for articulation   ith the two dorsal vertebræ above it.   The neck is the constricted part below the head.   The tubercle articulates with the transverse process of the corresponding dorsal vertebra.   The lower end is enlarged and has a rough cavity for the costal cartilage. The first rib is the shortest and is nearly straight, the others are more or less curved.

The **sternum,** or **breast bone,** is situated in the ventral part of the chest wall.   It is suspended by means of the ribs.   There are seven segments or sternebræ which never undergo complete

ossification. The upper surface is triangular in shape, narrow in front. The lateral surfaces present seven articular cavities for the cartilages of the true ribs. The inferior border is convex, keel-like, and may be distinctly felt in the living animal. Both extremities are cartilaginous.

BONES OF THE APPENDICULAR SKELETON

The *appendicular skeleton* comprises the bones of the thoracic and pelvic limbs.

A. The *bones of the thoracic* or *fore limb*, named from above downward, are the scapula or shoulder-blade, the humerus or arm, the radius and ulna or forearm, the carpus or knee, the metacarpus consisting of the cannon and two splint bones, the first phalanx or large pastern, the second phalanx or small pastern, the third phalanx or coffin bone, the proximal pair of sesamoids, and the distal sesamoid or navicular bone (Fig. 6).

The **scapula** is located on the anterolateral surface of the thorax. In the horse it is connected to the axial skeleton by muscles only. It is directed obliquely downward and forward. The scapula is a flat bone, triangular in shape, presenting for description two surfaces, three borders, and three angles. The external surface is divided into two unequal parts by the spine, a prominent ridge running lengthwise the bone. The narrow fossa in front of the spine is named the supraspinous fossa and the one posterior
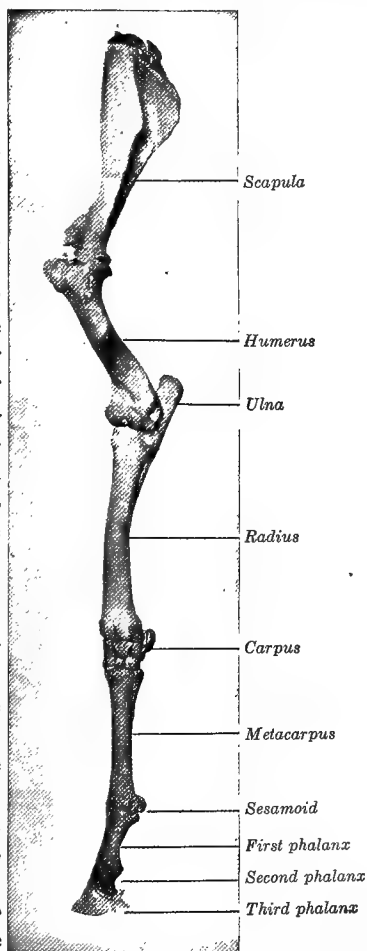
FIG. 6.—Skeleton of left fore limb of horse (lateral view).

Labels (top to bottom): Scapula, Humerus, Ulna, Radius, Carpus, Metacarpus, Sesamoid, First phalanx, Second phalanx, Third phalanx

to the spine the infraspinous fossa.   The internal surface is taken up by the subscapular fossa. Above on each side are two rough triangular areas for muscular attachment.   The superior border is thick and straight in the young and growing animal, but becomes uneven with age; it gives attachment to the scapular cartilage.   The anterior border is thin and rough in its upper part, concave and smooth below.   The posterior border is thick, concave, and rough.   The three angles are named anterior, posterior, and articular or humeral.   The articular angle carries a glenoid cavity for articulation with the head of the humerus.

The **humerus** is a long bone located between the scapula above and the radius and ulna below.   It is directed obliquely downward and backward.   This bone has a shaft or body and two extremities.   The shaft is twisted in appearance and has four surfaces.   The external surface is marked by the musculospiral groove.   The internal surface is rounded from side to side and presents above the middle the internal tubercle, and in its lower third the medullary foramen.   The anterior surface is flattened, wide above and narrow below.   The posterior surface is rounded and smooth.   The external border is the only distinct one and shows a large prominence, named the deltoid tuberosity.   The proximal extremity is very large and somewhat four sided; it presents an extremely convex head for articulation with the glenoid cavity of the scapula.   On each side of the head is a tuberosity; in front is a subdivided bicipital groove for the play of the tendon of the biceps muscle.   The distal extremity carries a pulley-like surface for the bones of the forearm.   Immediately above and behind this articular surface is the deep olecranon fossa.

The **radius** in the adult horse is united to the ulna to form what appears to be one bone, but in the fetus and young animal there are two distinct bones.   The radius is the larger in this animal. It is a long bone situated between the humerus and the carpus in a nearly vertical direction, and presents for description a shaft and two extremities.   The shaft is curved convexly foward, and has two surfaces and two borders.   The anterior surface is convex and smooth, while the posterior is concave in its length and flattened transversely.   On the external part of the posterior surface there is a rough area for the attachment of the ulna. The borders are rounded, the inner one is not covered by muscles. The upper extremity carries two shallow cavities for articulation

with the distal end of the humerus, the inner of which is the larger. Posteriorly are two facets for articulation with the ulna. In front at the inner side is the large bicipital tuberosity, to which the lower tendon of the biceps muscle is inserted. The distal extremity is composed of three facets for articulation with the proximal row of carpal bones.

The **ulna** is a reduced long bone occupying a position behind the radius and distal part of the humerus. It presents a shaft and two extremities. The shaft is three sided and tapers toward the lower extremity. The anterior surface is attached to the rough area noticeable on the corresponding part of the radius. The internal surface is concave and smooth, while the outer is flattened. The proximal extremity forms the bulk of the bone and projects upward and backward. Its summit is termed the olecranon process and corresponds to the "point of the elbow" in man. The anterior border bears the semilunar notch.

The **bones of the carpus** are either seven or eight in number and arranged in two rows. Named from within outward the upper row is composed of the radial, intermediate, ulnar, and accessory carpal bones; the lower row of the first, second, third, and fourth. The first carpal is often absent or the size of a pea. The carpus, as a whole, has four surfaces. The anterior surface is convex and lies further back than the distal end of the radius, thus affording protection to the joint when the animal falls on the knee. The posterior surface is very rough in the macerated state, but is leveled by the thick posterior ligament in the living animal. The upper and lower surfaces present a number of facets for articulation with the neighboring structures.

The **metacarpus** is composed of the cannon and two splint bones. Most mammals have five metacarpal bones, but the horse has only the second, third, and fourth. Number three, the large metacarpal or cannon bone, is the only one fully developed. The *cannon bone* is one of the strongest bones of the body, and is situated between the carpus above and the large pastern below. It presents for description a shaft and two extremities. The anterior surface of the shaft is smooth and rounded transversely. The posterior surface is rather flat and with the splint bones forms a shallow channel for the suspensory ligament. In the adult sometimes the small bones are firmly united to the cannon, causing the bony enlargement known as "splint." The

upper extremity presents several flat facets for the corresponding surface of the carpus, while the lower end has two condyles with a prominent central ridge for articulation with the pastern and two sesamoids. The *splints* are incompletely developed long bones and are three sided. The upper extremity of each is enlarged and articulates with the adjacent bones. The distal extremity is a small nodule which can be easily felt in the living animal by running the hand downward along the cannon, pressing gently with the fingers.

The **first phalanx,** or **large pastern,** is a long bone situated between the cannon and the small pastern in a direction obliquely downward and forward. It forms an angle of 50 to 55 degrees with the horizontal plane in well-formed limbs. The degree of inclination varies considerably in different horses. This bone presents for description a shaft and two extremities (see Fig. 73). The anterior surface of the shaft is convex, the posterior surface is flattened and roughened. The upper end consists of two shallow cavities with a deep groove between for articulation with the large metacarpal bone. The distal end is less extensive and articulates with the small pastern.

The **second phalanx,** or **small pastern,** has a very short shaft, and is partly enclosed by the hoof. The bone presents four surfaces. The proximal surface has two shallow cavities for articulation with the distal extremity of the first phalanx. The distal surface is molded for articulation with the coffin and navicular bones. The anterior and posterior surfaces are convex and slightly roughened.

The **third phalanx,** or **coffin bone,** is entirely concealed in the hoof, to which it closely conforms in shape (see Fig. 73). It presents three surfaces and two angles or wings. The articular surface has two shallow cavities for articulation with the small pastern, behind which is a flat area for the navicular bone. In front is seen the extensor process for attachment of the tendon of the extensor muscle. The anterior or wall surface slopes downward and forward and corresponds to the inner surface of the wall of the hoof; it has a rough, porous appearance due to its large number of foramina. The inferior surface is clearly divided into two parts by the semilunar crest which gives insertion to the deep flexor tendon. The anterior portion is vaulted, crescent shaped, and is termed "the sole surface," as it corresponds to the

horny outer sole. The posterior portion is less extensive and is named "the tendinous surface." The angles or wings project back on either side. The upper edge of each wing gives attachment to a lateral cartilage.

The **lateral cartilages** are two rhombic-shaped masses of cartilage which curve backward toward each other at the heel. The abaxial surface of each is convex; the axial is concave. These cartilages extend above the horny hoof wall and can be easily felt in the living animal. In their natural state they should be flexible. When they undergo ossification, "side-bone" is the result (see Fig. 73).

The **sesamoids** are two small bones which articulate with the distal end of the cannon. In their fresh state they are firmly bound together by a disk-shaped mass of cartilage over which the flexor tendons play.

The **navicular bone,** or **distal sesamoid,** is situated back of the coffin bone and lower end of the small pastern. It articulates with both of these phalanges. The deep flexor tendon plays over its posterior surface.

B. The *bones of the pelvic* or *hind limb*, named from above downward, are the os coxæ or hip, the femur or thigh, the patella or stifle, the tibia and fibula or leg, the tarsus or hock, the metatarsus or cannon, the first phalanx or large pastern, the second phalanx or small pastern, the third phalanx or coffin bone, the proximal pair of sesamoids, and the distal sesamoid or navicular bone.

The **os coxæ,** or **hip,** is a large, flat bone which forms part of the lateral wall and the entire ventral wall of the pelvic cavity. The right and left bones come together at the floor of the pelvis; their junction point is known as the symphysis. In the fetus three bones join to form each os coxæ, viz., the ilium, the ischium, and the pubis. These unite at a cavity named the acetabulum, which forms a socket for the head of the femur. A direct joint connects the os coxæ to the sacrum of the axial skeleton.

The **ilium,** the largest of the three bones of the os coxæ, slopes downward and backward. It is triangular in form and divided into a shaft and a wing. The shaft is three sided and joins the other two bones at the acetabulum. The wing presents two surfaces, three borders, and three angles. The dorsal surface is concave; the ventral surface is convex and carries a facet for articulation with the sacrum. All the borders are concave.

The internal angle is thick, forms the highest part of this region, and is known as the angle of the croup. The external angle is large and forms the prominence which, in the living animal, is

Femur

Patella

Fibula

Tibia

Hock

Metatarsus
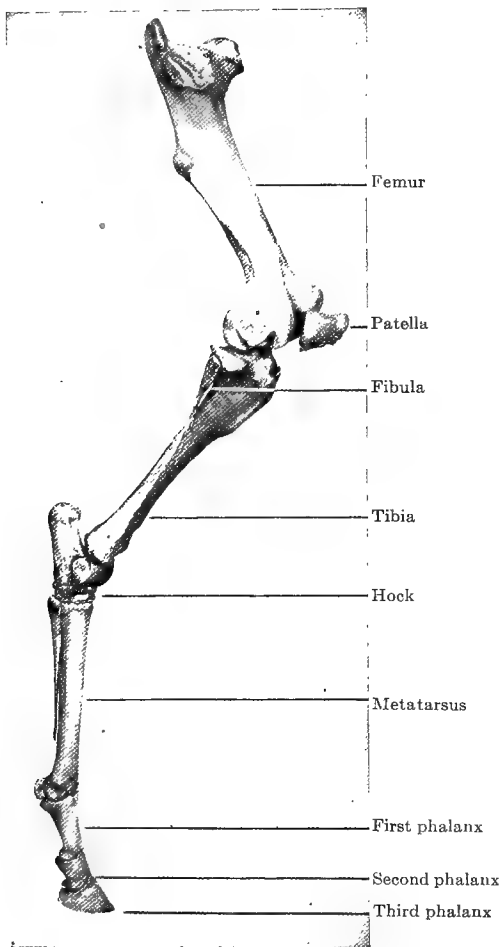
First phalanx

Second phalanx

Third phalanx

FIG. 7.—Skeleton of right hind limb of horse (lateral view).

referred to as the "hook bone," point of the hip, or angle of the haunch. The posterior angle connects with the shaft (see frontispiece).

The **ischium** is the most posterior of the bones of the pelvis. It is a flat bone having two surfaces and four borders. Both surfaces are nearly flat. The internal border is thick and rough and is united to its fellow of the opposite side by cartilage. The external border is concave, as is also the anterior, which forms the posterior margin of the obturator foramen. The posterior border is thick and rough. The large, rough tuberosity which projects backward and outward is the "pin bone."

The **pubis** is the smallest of the three and is placed at the anterior part of the floor of the pelvic cavity. Its dorsal surface is smooth, slightly concave, and supports the bladder. The ventral surface is convex and rough. The external angle assists in forming the acetabulum. The posterior border forms the anterior boundary of the obturator foramen.

The **femur,** or **thigh,** is the most massive bone of the body (Fig. 7). It is situated between the pelvis above and the tibia below, and slopes downward and forward. It is a long bone presenting a shaft and two extremities. The shaft has four surfaces and two borders. The anterior, internal, and external surfaces are convex, continuous, and smooth. The posterior surface is flattened and triangular in shape. The internal border carries in its upper third the small or internal trochanter, and a little below the middle the medullary foramen. The external border presents the large or external trochanter, below which is the deep supracondyloid fossa. The upper extremity is composed of the articular head adapted to the acetabular cavity, and the great trochanter at the outer side of the head. The distal extremity is very large and presents a double articular surface, consisting of the two condyles for articulation with the tibia, separated by the intercondyloid fossa, and the trochlea, situated anteriorly, for articulation with the patella.

The **patella,** or **stifle,** has an articular surface to fit the trochlea of the femur. It is pyramidal in shape with the base upward and corresponds to the knee-cap of man. This is the bone that is displaced in the condition known as "stifled."

The **tibia,** or **leg,** is a long bone situated between the femur and the hock in a direction obliquely downward and backward. It has a shaft and two extremities. The internal surface of the shaft is straight, not covered with muscle, and corresponds to the shin of man; the external surface curves to the front of the

bone, where it becomes flattened; the posterior surface presents several rough ridges and the nutrient foramen. The anterior border is prominent and forms the tibial crest. The upper extremity is large, three sided, and shows two saddle-shaped surfaces for articulation with the condyles of the femur; centrally, there is a pointed prominence; externally, there is a rough facet for the head of the fibula. The distal extremity carries an articular surface composed of two deep furrows with a ridge between for the tibial tarsal bone.

The **fibula** is a reduced long bone situated along the outer border of the tibia, with which it articulates at the proximal extremity. The distal extremity ends as bone about the lower third of the tibia, but is continued by a fibrous cord to the distal end of the tibia.

The **tarsus,** or **hock,** is composed of a collection of short bones situated between the tibia and the metatarsus. There are six or seven bones in the group, arranged in two rows, with a central bone between. The upper row is made up of the tibial and fibular tarsal bones, below which lies the central. The lower row is made up of the fused first and second, third and fourth tarsal bones.[1] The fibular tarsal is the largest and consists of a body provided with facets for articulation with the adjoining bones. Projecting upward and backward from the body is a prominence which corresponds to the heel of man. In the horse it forms the point of the hock. The tibial tarsal or knuckle-bone is the inner bone of the upper row. Its superior and anterior surfaces are continuous and form a trochlea consisting of two ridges, with a furrow between, for articulation with the distal end of the tibia. The central tarsal is situated between the two rows. The first and second are usually united to form a single bone. The third is somewhat like the central in form and appearance. The fourth is cubical in shape.

The **metatarsus** is composed, like the corresponding region in the fore limb, of the cannon and two splint bones. These bones are directed downward and a little forward. The hind *cannon* is about one-sixth longer than the fore. On cross-section it is more nearly circular in outline. The *splints* are larger and stronger,the external being relatively massive.

[1] These names apply when viewing the hock from the front and from within outward.

The digit of the hind limb is similar to that of the fore The principal differential features lie in the third phalanx, which has a less oblique wall, a narrower toe, and a sole surface that is more concave. The distance between the angles or wings is also less.

THE SKELETON OF THE OX

There are only a few marked differential features between the bones of the horse and those of the ox.
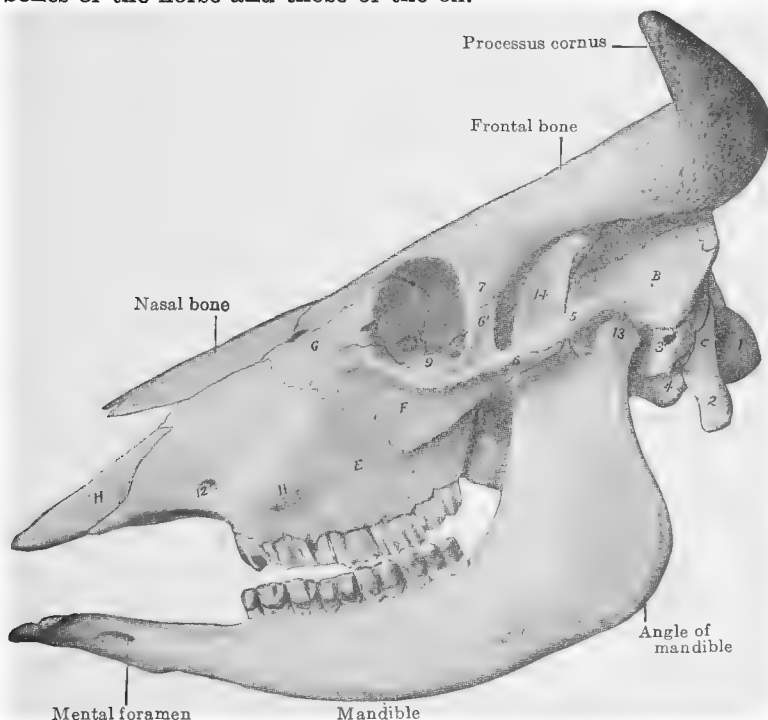
FIG. 8.—Skull of ox; lateral view: A, parietal bone; B, temporal bone; C, occipital bone; D, palatine bone; E, maxilla; F, malar bone; G, lacrimal bone; H, premaxilla; 1–11, processes; 12, infraorbital foramen; 13 and 14, processes of mandible. (Sisson, Anatomy of Domestic Animals.)

In the horned breeds of cattle the frontal bones present the horn processes or "horn-cores" for the support of the horns.

The premaxillæ are thin and flat in front and have no alveoli since the canine and upper incisor teeth are absent (Fig. 8).

The vertebral formula for the ox is $C_7T_{13}L_6S_5Cy_{18-20}$.

The ribs number thirteen pairs. They are longer, wider, flatter, and less curved than in the horse.

The scapula has a larger spine which is placed nearer the anterior border and has a prominent projection below.

The humerus has a less prominent deltoid tuberosity than in the horse and has a hook-like process which curves over the bicipital groove.

The radius is short, relatively broad, and fuses its entire length with the ulna, which is more fully developed than in the horse and articulates with the ulnar carpal.

The carpus consists of six bones, four in the upper row and two in the lower.

The metacarpus consists of a large bone, formed by fusion of the third and fourth bones of the fetus, and an external splint corresponding to the fifth metacarpal of five-toed vertebrates. The cannon has a distinct vertical groove which marks its double origin.   At the distal end it is divided into two parts by a deep notch.   The splint is only about one inch long.

The digits of the ox are four in number.   Of these, the third and fourth are fully developed and have three phalanges each. The second and fifth are vestiges placed behind the fetlock and do not articulate with the rest of the skeleton.

The ilia are parallel to each other and relatively small.

The femur is shorter and much smaller than in the horse.

The tibia has a curved shaft and the grooves at the distal end are directed nearly straightforward.

The other bones of the hind limb resemble those in the fore limb.

THE CONSTRUCTION AND WORK OF THE JOINTS

A *joint* is the union of two or more bones or cartilages.   Joints are classified, according to structure, into three types:

Type I, immovable, in which the opposed surfaces are directly united by connective tissue, *e.g.*, joints between the bones of the skull.   The periosteum also assists in this union.

Type II, slightly movable, in which the bones are united by cartilage that is elastic enough to permit a slight movement, *e.g.*, the intervertebral joints.

Type III, freely movable, in which a joint cavity[1] exists between the opposed surfaces, *e.g.*, hinge-joint, as that of the

[1] The joint cavity is a potential cavity and does not actually exist in the sense of a space occupied by air.   When the bones of the articulation are forcibly pulled apart there may be a small space, but it is largely filled with synovia.

elbow; and ball-and-socket joint, as that between the pelvis and the femur at the hip.

The **freely movable joints** are the only true joints (Fig. 9). They are composed of the following structures:

1. Two or more bones with joint surfaces that are usually somewhat expanded.

2. Articular cartilages, which cover the articular surfaces of the bones. These are exceedingly smooth and are thickest on the central part of a convex surface, while on a concave surface the marginal cartilage is thickest. They diminish the effects of concussion and greatly reduce friction.

3. A joint capsule, which resembles a sac open at both ends, is attached around the articulating surfaces. It is composed of two layers—an external, strong fibrous layer, and an internal, velvety synovial layer.

4. Ligaments, strong fibrous bands which bind the bones firmly together. They are pliable, but

FIG. 9.—Diagram of section of true joint: *f.l.*, Fibrous layer; *s.l.*, synovial layer of joint capsule. The articular cartilages are white, bones dotted, and joint cavity black in the figure. (Sisson, Anatomy of Domestic Animals.)

inelastic, and maintain the articular surfaces in more or less close contact and thus greatly strengthen the joint. In most joints the ligaments lie external to the joint capsule. In others, such as the hip and stifle, they lie within the joint-capsule.

Synovia is a viscid, straw-colored fluid which gives an alkaline reaction. It is not secreted by glands but is a tissue fluid that exudes into the joint. It contains proteins, salts, and mucin. Synovia reduces friction by lubricating the joints. The amount of synovia increases and diminishes to a certain extent under normal conditions. When an excessive quantity is present a puffy swelling occurs in the region of the joint. Bog spavin is a good example of an excess in the hock-joint.

All **joint movements** are due to muscle contraction and relaxation. True joints are found to vary greatly in their possibilities for movement depending upon the location and extent of their ligaments. The seven principal kinds of joint movements are:
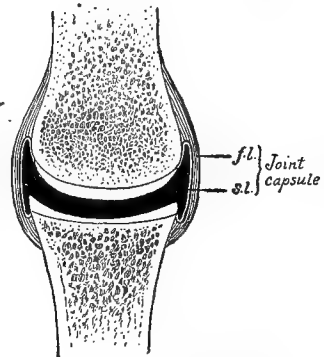
1. Gliding, the simplest and only movement possible between two plane or undulating facets.

2. Flexion, which brings two bony pieces nearer each other by closing the angle more or less.

3. Extension, the reverse movement by which the bones are straightened on each other.

4. Adduction, which brings the inferior end of the movable bone toward the median plane of the body.

5. Abduction, where it has the opposite effect.

6. Circumduction, in which the shaft of the distal bone of the joint describes the surface of a cone.

7 Rotation, in which one bone pivots or rotates on the other.

DESCRIPTIONS OF IMPORTANT JOINTS

The shoulder, fetlock, pastern, and coffin joints of the fore leg; and the hip, stifle, and hock joints of the hind leg are the most important, for they are largely concerned in the mechanism of locomotion. As we have already learned about the shape of the articular surfaces of the bones which enter into these joints, it will not be necessary to describe them again.

The **hip-joint** of the horse in addition to the usual articular cartilages has an accessory cartilage which plays an important part in its work. It is in the form of a marginal ring of fibro-cartilage, which very appreciably deepens the acetabulum and makes dislocation extremely difficult if not impossible. The articulation is of the ball- and socket-type and is capable of all the movements just described except gliding.

The **stifle joint** of the horse is the largest and most elaborate of all the articulations. Its synovial sac is the largest found in any joint. This is because it comprises two joints, the femoro-patellar and the femorotibial. Two *C*-shaped accessory cartilages are placed between the femur and tibia to adapt them more properly to each other. Two strong rounded cruciate ligaments bind the femur to the tibia. The principal movements of the stifle are flexion and extension (see Fig. 75).

The **hock-joint** of the horse is another complex and important joint. On it the strain of propulsion chiefly falls and the jar which results from concussion during the act of progression is largely broken. The movements are confined mostly to flexion and extension. When the animal moves the joint opens and closes simultaneously with the stifle.

CHAPTER III

THE MUSCULAR SYSTEM

KINDS OF MUSCLES

The *muscular system* is the largest in point of weight of all the body systems. It is composed of a great many separate
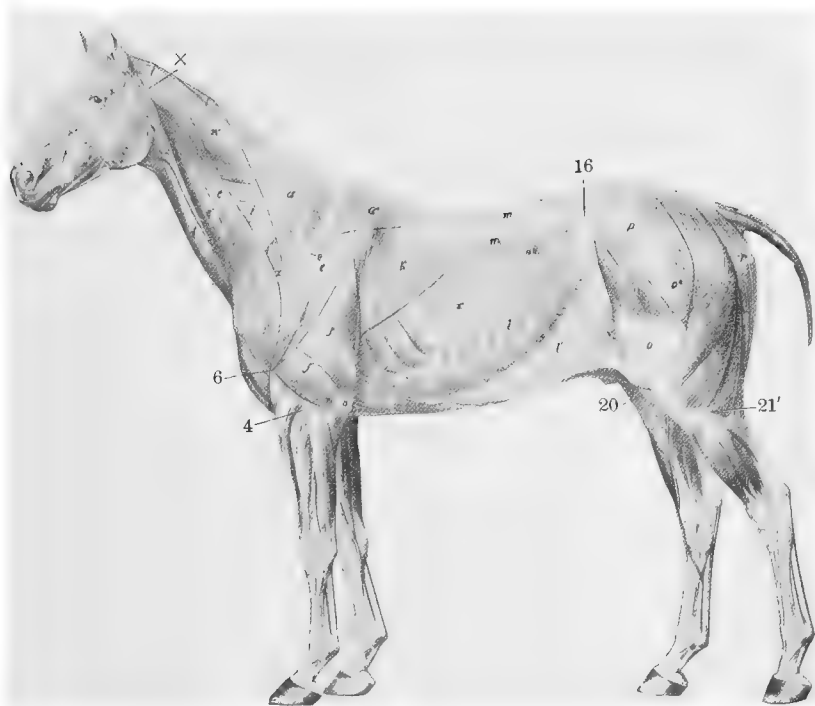
Fig. 10.—Superficial layer of muscles of horse: ×, Wing of Atlas; 2, spine of scapula; 4, condyle of humerus; 6, deltoid tuberosity; 8, olecranon; 16, external angle of ilium; 20, patella; 21′, lateral condyle of tibia. (Ellenberger-Baum, Anat. für Künstler.)

muscles which belong either to the skeletal or visceral group of muscles.

The **skeletal muscles** comprise all the flesh or lean meat of the body and represent 45 per cent. of the body weight (Fig. 10).

53

They may be said to clothe the skeleton more or less completely except the bones of the lower limbs, which are covered only by tendons and skin.

The **visceral muscles** are found in the walls of the stomach, intestines and other hollow organs. They are much less bulky than the skeletal muscles, but are more important from the standpoint of maintaining life.

Muscular tissue is reponsible for all movements, both voluntary, such as walking and jumping, and involuntary, such as the circulation of the blood through the heart and movements in all the other internal organs. Since the other body tissues are their servants, the muscular and nervous tissues are known as the master tissues of the body.

There are three distinct kinds of muscles, viz., (1) voluntary, striped or striated, (2) involuntary, unstriped or smooth, and (3) heart muscle, striped, but involuntary.

THE VOLUNTARY MUSCLES

These muscles are under the control of the will and by acting on the bony levers enable the animal to move from place to place as his brain directs. The properties of voluntary muscles are assembled in the following outline:

Location.—The voluntary muscles are located external to the skeleton, so are often referred to as the skeletal muscles.

Color.—This varies with the age of the animal and work the muscles perform. In mature horses voluntary muscles are dark red to brown. When exposed to the air they acquire a bluish luster. The meat of a bull's carcass is darker than that of a steer's or a cow's. Lean meat from a calf is lighter in color than that of older bovines, as the muscles are undeveloped.

Volume.—This varies with the location and the work performed. Some muscles are very small in size and extremely delicate, while others are large, strong, and powerful, for example, those of the thigh.

Form—The usual forms are long, short, flat, and ring-like. Examples of the first are found in the limbs, of the second and third between the ribs, and of the last at the natural body openings.

Shape.—The usual shapes are simple and digastric; biceps, triceps, and quadriceps; penniform and semipenniform.

Structure.—Like all other organs, muscles are composed of several types of tissue. White fibrous tissue forms a covering, called the perimysium, for the muscle. On close examination the muscle is found to be composed of numerous bundles of fibers of muscular tissue. Each bundle is in turn made up of smaller bundles, which are composed of separate fibers. These extremely minute fibers are similar to a cylindric thread and are about 2 inches long and $\frac{1}{500}$ inch thick. The bundles have a delicate sheath or covering, the sarcolemma. Under the microscope fine striations are seen at right angles to the long axis of the fibers, hence the name striated or striped (Fig. 11). When a muscle is subject to much strain, tendinous fibers are mixed with the fleshy fibers.

Attachments.—These may be direct to other muscles or to cartilages or bones, or indirect by means of tendons. Tendons are rounded or flattened cords fitted to the fleshy ends of muscles. The attachments determine the direction, extent, relation, and, in part, the uses of muscles. The point of attachment which usually remains fixed is termed the origin; the point that is displaced when the muscle contracts is the insertion. Tendons are usually less extensive than the fleshy part of the muscles which they continue; this permits many muscle attachments to a relatively small surface.

Nerve Supply.—The nerves of muscles are derived from both sensory and motor nerve centers in the brain and spinal cord. The sensory nerves convey sensations of muscle tension and condition to the brain, but their endings in the muscle are not very sensitive to mechanical injury. The motor nerves supply impulses originat-
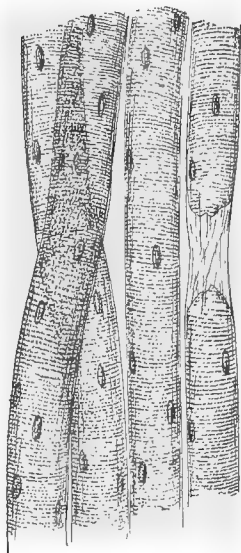

Fig. 11.—Portions of four fibers of skeletal muscle. If carried out to their ends these would be several feet long for they are often as much as 500 times longer than they are in diameter. Two are crossed to suggest their relative transparency. The one at the right has been injured and the sarcolemma remains spanning a break in the striated protoplasm. (Stiles, Human Physiology.)

ing in the brain. When they are cut or interfered with the muscle becomes paralyzed.

Blood Supply.—A plentiful supply of blood is furnished through the arteries of each muscle and is removed through the corresponding veins (Fig. 12).

Arrangement.—Muscles are arranged in groups of two, one group acts in opposition or is antagonistic to the other. The effectiveness of this arrangement is seen in the precision of locomotion.
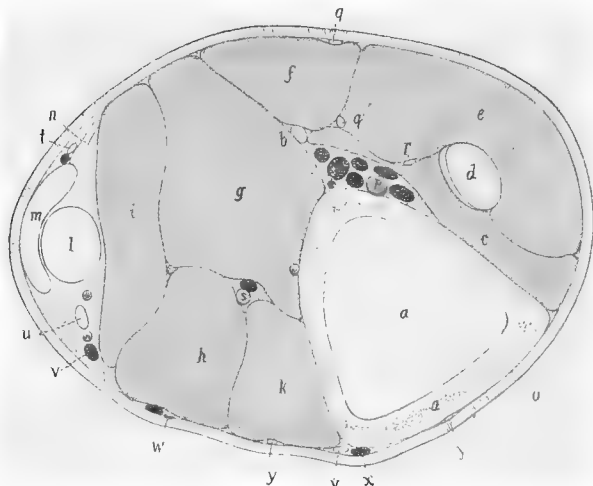
Fig. 12.—Cross-section of left leg of horse, cut a little above middle: a, Tibia; b, fibula; d, l, m, tendons of muscles; c, e, f, g, h, i, k, n, fleshy portions of muscles; o, skin; p, s, w, arteries; v, x, veins; q, q', r, t, u, y, nerves. (Ellenberger in Leisering's Atlas.)

Accessory Structures.—To facilitate the play of a muscle or tendon over bony prominences bursæ and tendon sheaths are provided. *Bursæ* are small sacs filled with a fluid which resembles synovia. They form pads to prevent friction. The *tendon sheaths* are elongated, closed sacs containing serous fluid. They are folded completely around the tendons, as the diagram (Fig. 13) shows.

Names.—Each skeletal muscle has a name. Names of muscles have been handed down from the earlier anatomists, who

gave them in a haphazard manner. Some were based on form, location, and function; others have been adopted from human anatomy and do not apply to quadrupeds, so there has been little uniformity in muscle terminology.

Fibrous sheath Synovial bursa Mesotendon Fibrous sheath Synovial sheath Bone Bone

A B

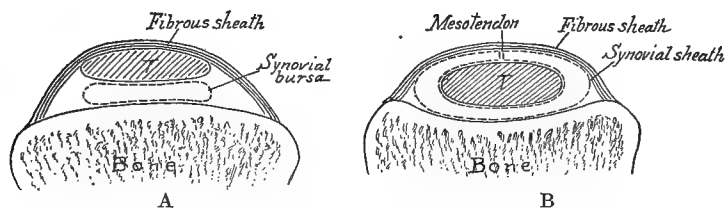Fig. 13.—Diagram of cross-section of bursa (A) and tendon sheath (B): *T*, Tendon. For the sake of clearness the synovial sacs are represented as somewhat distended. (Sisson, Anatomy of Domestic Animals.)

In the following classification of the chief muscles of the fore limb of the horse, which is given to illustrate the general arrangement of muscles, the names are those given preference in Sisson's "Anatomy of the Domestic Animals:"

Flexor Muscles of the Elbow:
 1. Biceps brachii.
 2. Brachialis.

Extensor Muscles of the Elbow:
 1. Tensor fasciæ antibrachii.
 2. Triceps brachii.
 3. Anconeus.

Flexor Muscles of the Carpus:
 1. Flexor carpi radialis.
 2. Flexor carpi ulnaris.
 3. Ulnaris lateralis.

Extensor Muscles of the Carpus:
 1. Extensor carpi radialis.
 2. Extensor carpi obliquus.

Flexor Muscles of the Digit:
 1. Superficial digital flexor.
 2. Deep digital flexor.

Extensor Muscles of the Digit:
 1. Common digital extensor.
 2. Lateral digital extensor.

In addition to these muscles of the fore limb, attention is called particularly to the heavy muscles of the haunch and thigh, where the propelling power lies. Notice is also directed to the relation beween the development of these muscles and the conformation of the animal's body.[1]

[1] Those who wish to go into this subject more fully are referred to text-books on veterinary anatomy.

THE INVOLUNTARY MUSCLES

Instead of being under the direct control of the will, as are the voluntary muscles, the involuntary muscles act independently. Their properties may be contrasted with the voluntary as follows:

Location.—The walls of all hollow organs such as the stomach, intestines, bladder, bronchial tubes, arteries, and veins contain involuntary muscles. Since they occur only in soft organs, they are known as visceral muscles.

Color.—Their color is pale or light red.

Volume.—They are found in relatively small masses.

Form.—They conform to the form of the walls of the organs in which they are located.

Shape.—They are always found in thin sheets or tubes.

Structure.—Involuntary muscles are composed of spindle-shaped cells about $\frac{1}{250}$ inch in length, each cell having a single nucleus (Fig. 2). These cells are grouped together so as to give the appearance of a smooth layer, hence the name smooth or unstriped muscle. The sarcolemma is thin but tough and elastic and adapted to the surface of each cell.

Nerve Supply.—This comes directly from the sympathetic nervous system instead of from the central nervous system, as in the case of voluntary muscles. Numerous ganglion cells are distributed throughout involuntary muscles.

Blood Supply.—Nutriment is supplied by many very minute blood-vessels.

Arrangement.—They are always arranged in two layers in the walls of the soft organs, viz., an outer longitudinal and an inner circular layer (Fig. 25).

Names.—When there are any given, the names correspond to those of the organs in which the muscles are located.

THE HEART MUSCLE

Cardiac muscle is midway between the voluntary and involuntary muscles. It resembles the former in being composed of striped fibers and the latter in not being under the control of the will. The grouping of the individual fibers, however, differs somewhat from that of typical striped muscle. The nerve supply is in part from the vagus nerve of the central nervous system and in part from the sympathetic system; impulses from the former inhibit the heart muscle contractions, while those from the latter augment or accelerate them.

THE PHYSIOLOGY OF MUSCLES

The great size of the muscular system is an indication of its physiologic importance. The most essential properties and functions of muscles will now be discussed.

Extensibility and **elasticity** are characteristic properties of all kinds of muscle. The former is the property of stretching; the latter the property of returning to the original shape after stretching. These properties can be demonstrated best by applying a
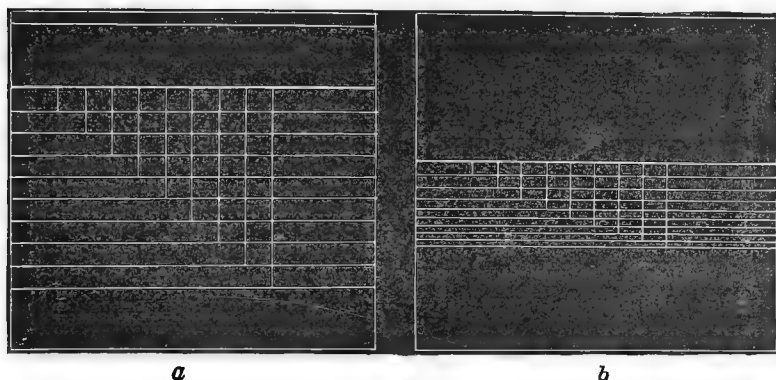
FIG. 14.· Curve of extension of a rubber band, to show the equal extensions for equal increments of weight. The band had an initial load of 17 gms., and this was increased by increments of 3 gms. in each of the nine extensions, the final load being 44 gms. The line joining the ends of the ordinates is a straight line. b, Curve of extension of a frog's muscle (gastrocnemius). The initial load and the increment of weight were the same as with the rubber. The curve shows a decreasing extension for equal increments. The line joining the ends of the ordinates is curved. (Howell's Physiology.)

weight to living voluntary muscle, which will extend under the strain. When the weight is removed, the muscle returns to its original form by virtue of its elasticity. The extensibility of such a muscle is great, but the elasticity, though perfect, is slight. In the living animal muscles are normally on the stretch. This is seen by cutting across the belly of a muscle when a noticeable gap occurs between the severed ends. This elastic tension insures almost instantaneous action when the muscle is brought into play for there is no slack to be taken up. The muscle stands as if it were at full cock. We have seen that muscles are arranged

in groups of flexors and extensors that oppose each other so that the contraction of one group moves the bone against the pull of the extensible and elastic antagonist.   This enables the muscles to move the bony levers with greater facility, smoothness, and effectiveness.   The accompanying charts show that muscle elasticity is not like that of a dead elastic body (Fig. 14).

Muscular contraction depends upon the properties of irritability and contractility, both of which are well developed in the muscles.   Irritability is the property of response to stimulation by outside objects.   Contractility is the property of muscle which is manifested after it receives a stimulus.   It results in the muscle shortening in length and increasing in thickness, *i.e.*, the two ends are brought closer together.   It is normally due to a stimulus received from the central nervous system through motor nerves.   When these nerves are severed, the muscle is said to be paralyzed.   However, experiments with thermal, mechanical, and electrical stimuli show that muscles, whose connection with the central nervous system is cut off, are capable of independent contraction.   Thermal stimulation resulting in contraction is seen when an animal is butchered—the cold air coming in contact with the recently exposed flesh sets up a pronounced twitching. Another example is "shivering" due to sudden exposure of the skin to cold.   Mechanical stimuli, such as a sharp blow or a pinch, will cause a contraction in the muscles.   Electrical stimuli are most suited for the experimental study of the duration, extent, speed, and strength of contraction, because their intensity can be controlled so as not to injure the muscle substance.

The duration of a simple contraction varies in muscles from different parts of the same animal.   There is little difference, however, in the length of the period in long and short muscles, as they contract throughout their entire extent at nearly the same moment   Ordinarily it does not last longer than the fraction of a second.   Contraction may be voluntarily maintained for a considerable period and is shown by the muscle being hard to the feel.   Relaxation always follows contraction so that the muscle may recuperate.

The extent of contraction is about one-third the length of the muscle, *e.g.*, a muscle 3 inches long can shorten 1 inch, while one 6 inches in length can shorten 2 inches.   In other words, the range of contractility in a long muscle is greater than in

a short one, and the part to which it is attached is moved farther. When the load is increased, the extent of contraction is diminished.

The speed and strength of the contractile power depend on the tonicity of the muscles, their length, and their massiveness. A horse with long legs can develop greater speed than one with short legs, provided the muscles of each are of equal tone. This is due to the greater length of the tendons which act to better advantage on the bony levers. On the other hand, if two muscles of the same length and power of contraction are compared, the greater strength will be developed by the one with the more volume. In other words, the strength of a muscle is in proportion to its thickness or massiveness. From this discussion we may summarize as follows: Muscles of strength are short and thick, those of speed are long and slender. These facts are clearly demonstrable by comparing the draft horse, which has heavily developed muscles and wonderful ability to pull heavy loads, with the race-horse which has long, slender muscles, and limbs that give a wide range of action and develop a much higher rate of speed.

THE CHEMICAL COMPOSITION OF MUSCLES

The **chemical elements** of which the muscles are composed in general are the same as those of the entire body (see Chapter I). They consist for the most part of carbon, hydrogen, oxygen, nitrogen, sulphur, and phosphorus in various combinations.

The **inorganic compounds** of muscles are water, which comprises about 75 per cent. of fresh muscle, and salts, which exist chiefly in the form of the potassium salts of phosphoric acid. Small traces of calcium, magnesium, and iron are also present, but are of minor importance as they are in most other tissues except bone.

The **organic compounds** of muscles consist of a variety of substances, the most important of which are the following: (1) Muscle proteins, which constitute about 20 per cent. of muscle tissue, are found as myosin and myogen. They may be obtained for study by expressing the juice or plasma from muscle. (2) Carbohydrates are in the form of glucose and glycogen. The presence of considerable sugar in horse meat gives it a peculiar sweetish taste. (3) Fat is found in very small quantity in the

muscle fibers. (4) Organic extractives are present in various combinations. The most plentiful of these is creatin, a product of metabolism. To some of these extractives meat juice owes its property to stimulate appetite; they are increased to some extent during the ripening of meats. Others are probably responsible for the unpleasant odor of muscle tissue from certain animals. (5) Sarcolactic acid occurs in small amount in all living muscles. (6) Pigments peculiar to the muscles give them a red color, but the presence of the hemoglobin or red coloring matter of the blood is partially responsible for the redness.

THE CHEMICAL CHANGES OF MUSCLES

Chemical changes of various kinds are constantly taking place in living muscles. They lead to the formation of products that act as poisons unless removed before accumulated to excess. A normal resting muscle when isolated from the body gives an alkaline reaction. After it has been stimulated and caused to contract it becomes acid. This change in reaction cannot be detected in the body because the alkaline tissue fluid, which bathes the muscle-cells, at once neutralizes the acidity. The two acids which are responsible are, carbonic and sarcolactic. Carbonic acid (CO_2) arises from the oxidation of the carbon-containing constituents of the muscle. Its formation is always accompanied by the production of heat and involves an exchange with oxygen. Sarcolactic acid ($C_3H_6O_3$) is a product of muscle activity. Another chemical change that occurs during activity is the gradual conversion of the glycogen, which is stored in the muscles during rest, into glucose to supply energy. If the activity is long-continued not a trace of glycogen remains. The only other chemical change that need be mentioned is the production of energy, which, although left for last consideration, is the most important from an economic viewpoint.

Muscular energy is exhibited either as heat production or as work performance. Under controlled conditions both forms can be measured quantitatively and expressed in definite units. The unit of heat, known as the calorie, is the amount of heat necessary to raise one gram of water one degree Centigrade. The unit of work, known as the kilogrammeter, is the amount of work done in lifting a kilogram to the height of one meter from the surface of the earth against the attraction of gravity. The muscles

cannot manufacture or destroy energy; neither can a steam engine. Muscular energy is derived from the oxidation in the muscle of organic substances derived from the food.   The necessary oxygen comes from the lungs and is carried to the muscles by the red blood corpuscles.   The great law of conservation of energy in nature which states that energy can neither be created nor destroyed, is followed in the animal body.   The nutrients in the hay and grain which the animal consumes are oxidized and the stored or potential energy in them is liberated as free or kinetic energy.   This oxidation process results in the formation of new but simpler chemical compounds, chief of which, as has been stated, are carbon dioxide gas and sarcolactic acid.

Heat production in the body is largely the result of muscular activity.   It follows that the more active the muscles are, the more heat will be produced.   Some authorities consider the heat produced by muscles to be a by-product, for the most part, as less than half of that formed is required for the maintenance of the normal temperature of the body.   The balance cannot be utilized so is liberated through radiation and conduction.   Heat energy is sometimes called internal work, but this term also applies to the actual work of the visceral organs, so is now less frequently used in this connection.

Work performance of muscle is that force that is exhibited when muscle contracts.   Only that produced by the voluntary muscles will be considered, i.e., external or direct work like locomotion or pulling a load.   Work is of great economic importance in beasts of burden.   Various devices for measuring it have shown that it varies with the load.   When a muscle contracts against too heavy a load, no actual work is produced, but much heat is generated.

Of practical importance is the question how much of the energy liberated by a muscle is available for external work, and how much is lost as heat?   In attempting to answer this question it should be realized that the generation of heat and production of work in the body follow the same laws that govern these forces in artificial motors like steam and gasoline engines, but combustion in the living organism is not such a simple process.   The food, before it reaches its final end products, undergoes a series of chemical changes of varying energetic significance.   In the engine the heat derived from the chemical energy of the fuel is the motive

power and no differentiation is made between fuel.   In the or-
ganism the food is not only heat-producer, but tissue-builder,
repairer, and generator of new organisms of a similar type.
From these statements it is clear that muscle is a chemical-engine
and not a heat-engine.

A muscle supplied with fuel has been found by various methods
of study to produce about 66⅔ per cent. of the heat which the
same material would produce when burned.   The balance, or
33⅓ per cent., is convertible into work.   Most steam engines
can use only about 6 per cent. of the energy in fuel for mechanical
work, the rest is lost as heat.   Accordingly, muscles are more
economical workers than steam engines and in addition they have
the further advantage of being able to utilize part of the liberated
heat to maintain the temperature of the body, which is necessary
for life-processes.

Muscular fatigue follows continued work.   This is either due
to the accumulation of products of activity, or to the using up
of substances from which energy is derived.   The latter results
in *muscular exhaustion*.   If time be allowed for rest, the
accumulated waste products are removed by the blood and
lymph, a fresh supply of nutrients is brought to the organ,
there is a rapid renewal of irritability and contractility, and a
feeling of "fitness" prevails.   The experiment of tying off one
leg of a frog and injecting extract of a fatigued muscle shows
clearly the effect that these products have on muscular activity.

Hand-rubbing the legs of horses is beneficial because the blood-
and lymph-vessels are stimulated to increased activity in the
removal of waste products, and in causing the blood to circulate
more freely.   Fatigue may be in part overcome by providing a
feed of a readily available carbohydrate, such as molasses, which
is quickly converted into glucose, in which form it may be at
once utilized by the cells of the body for nutritive purposes.

Experimentally, the course of fatigue in a muscle may be
studied by causing an isolated muscle to contract to its limit, at
regular intervals, against the resistance of a spring.   The length
of the successive contractions is recorded on the smoked surface
of a slowly revolving cylinder.   A fatigue tracing of this kind
shows that continuous work by a muscle removed from the body
and, therefore, not supplied with blood, finally results in the mus-
cle's refusal to respond to stimulation.   On the other hand, if

a similar tracing is taken from a muscle with its circulation intact, a fatigue level of working power will be found. This proves that the blood furnishes substances to maintain the working power of muscles and removes the wastes.

A "green" horse—that is, one not accustomed to steady work—fatigues much quicker than a "hardened" horse, because his muscles are softer and carry an excess of fat. By working such a horse moderately, with properly spaced periods of rest, it is possible to build up the muscle cells so that he can do as much work as the "seasoned" animal. Rest gives an opportunity for the muscles to repair themselves. During rest, as has been shown, the blood furnishes new food to build up the worn and broken-down cells and oxygen to furnish life. It should be remembered that fatigue increases with the square of the amount of work done and not in direct proportion. Furthermore, there is a limit to continued muscular effort, and harmful fatigue can be avoided only by working the horse at a moderate rate, so as to keep a balance between the products of muscular activity and the ability of the blood to remove this waste material and provide fuel. An animal should under no circumstances be worked until exhausted, for it is inhuman as well as uneconomical.

Rigor mortis is the condition of stiffness which the muscles usually assume soon after death. It is probably due to the coagulation of myosin and other muscle proteins through the formation of sarcolactic acid. The process changes both the physical properties and the chemical reaction. The muscles become firm and unelastic to the touch, and give an acid reaction. During death-stiffening carbon dioxide, sarcolactic acid, and heat are produced. In some cases the after-death temperatures are very high. The muscles of the head are first affected. From here the change rapidly spreads backward to the body muscles. The time when rigor mortis appears depends upon the activity of the muscles just before death; the greater this has been, the sooner rigor sets in and the longer it lasts. Animals which have died from exhaustion or severe febrile disease show little rigor mortis; it appears very soon and passes off quickly. In such cases decomposition changes set in almost immediately as the bacteria present in the body find conditions suitable for their rapid growth and multiplication. When rigor mortis disappears the muscles become soft and the body limp. The phenomenon of contraction is occasionally

5

observed in the muscles after death.   It is caused by a shortening of the muscles as a result of postmortem changes and brings about movements in the carcass that resemble those of life.   When it occurs in the corpse of a man watchers at the bier are often horrified.

A summary of the chemical changes normally taking place in living muscles follows:

1. The oxygen, which is brought to the muscles from the lungs, is used for the combustion of the carbohydrates, proteins, and fats brought from the intestines.

2. The stored glycogen is converted into glucose.

3. The products of these chemical changes are carbon dioxide, water, sarcolactic acid, and energy.

4. The energy produced is in the form of heat and work.

In the absence of food, muscles produce heat and perform work at the expense of their stored-up carbohydrates.   Except in starvation, the proteins do not furnish energy as there is no provision for their storage.

The **physiologic properties** of involuntary muscles differ in some respects from those of the voluntary group.   The chief differences are their power to remain contracted for a long period and their great rhythm and force of movement.   Response to stimuli is from one hundred to five hundred times slower, but it occurs with greater regularity, is more marked, and lasts longer.   This is seen by pinching the exposed intestine or rubbing the hand over the stomach wall, when peristaltic movements immediately set in.

Heart muscle contracts slower than voluntary but faster than other visceral muscles.   Its property of rhythmic contractility is developed to a wonderful degree.   When the heart contracts at all it does so to its utmost ability.   Other functions of heart muscle will be taken up when the circulation of the blood is studied.

THE DIGESTIVE SYSTEM

THE ALIMENTARY CANAL

The *digestive system* is represented by a tube about 100 feet long, open at both ends, looped on itself many times, dilated at intervals along its course, and provided at various places with accessory glandular organs that pour their secretions into the tube to aid digestion. The anterior opening is for the reception of food; the posterior, for the expulsion of the unabsorbed portion and wastes. The tube is commonly known as the **alimentary canal.**

Mucous membrane lines the alimentary canal throughout its length. This is a moist, velvet-like tissue with an inner or free surface which is usually thrown up into folds. These folds provide a means of increasing the area through which absorption of the products of digestion occurs. They become effaced with the distention of the walls of the organs with food or gas. At the natural body openings the mucous membrane is continuous with the external skin. It has been called the "internal skin." Its color, thickness, and other characters vary in different organs, depending on the functions which it has to perform. The contents of the canal are not to be considered as within the body but only in contact with a part of its surface.

External to the mucous lining is found a double layer of involuntary muscle-fibers, composed of an inner circular and an outer longitudinal layer (see Fig. 24). Through the alternate wave-like contraction and relaxation of these muscle-fibers the food is thoroughly mixed with the digestive juices, and conveyed along the canal from organ to organ.

A **serous membrane** covers the alimentary canal in the greater part of its course. This is a thin, transparent, shiny, and smooth tissue which is reflected from the walls of the body cavities. It serves as a covering for the soft organs in these cavities and acts as a lining for their walls. Its free face is always in contact with itself. From it is secreted a serous fluid that keeps the membrane moist and allows the viscera to glide freely upon each other.

67

The rapidity with which serous membranes absorb fluids makes them very sensitive to infection. They never come in contact with the external air.

The **peritoneum** is the name given to the serous membrane lining the *abdominal* and *pelvic cavities*. The most satisfactory way to understand the general disposition of it is to think of the cavity as empty and lined by a single layer of peritoneum (Fig. 15). The organs may be regarded as beginning to develop outside this membrane, and, as they enlarge, gradually push
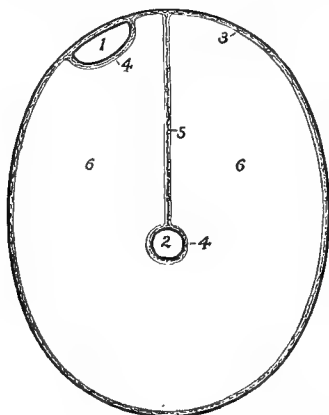
FIG. 15.—Diagrammatic cross-section of abdomen to show arrangement of peritoneum when reduced to its simplest form. The external black line represents the body wall: 1, Organ (*e.g.*, kidney) in contact with wall; 2, organ (*e.g.*, small intestine) at a distance from wall; 3, parietal peritoneum; 4, visceral peritoneum; 5, mesentery; 6, peritoneal cavity. (Sisson, Anatomy of Domestic Animals.)

into it and become enveloped by it. This causes folds of the peritoneum to connect the organs with the wall or with each other. The connecting folds are termed *omenta, mesenteries*, and *ligaments*. They contain fat in varying quantities, depending upon the condition of the animal, and furnish a path for vessels and nerves. The principal peritoneal folds are the **great omentum,** the large lace-like membrane behind the stomach, and the **great mesentery,** which suspends the small intestine from the roof of the abdominal cavity. In the ox the great omentum is commonly known as the caul.

A **viscus** is any large interior soft organ of the body. Abdominal viscera are the organs comprising the digestive system contained in the abdominal cavity.

THE ORGANS OF DIGESTION

The organs of digestion may be conveniently grouped into

Alimentary Organs:
1. Mouth
2. Pharynx
3. Esophagus
4. Stomach
5. Small intestine
6. Large intestine

Accessory Organs:
1. Tongue
2. Teeth
3. Salivary glands
4. Liver
5. Pancreas
6. Intestinal glands

The **mouth** is a cylindric cavity situated between the two jaws, elongated in the direction of the long axis of the head. It has an anterior opening for the introduction of food, and a posterior one that communicates with the pharynx. When closed, the mouth is nearly filled up by the teeth and tongue. It is guarded in front by the lips and laterally by the cheeks.

The **lips** are designated *superior* and *inferior* from their positions. On the outer surface of the lips are found many fine, short hairs; also a number of long bristle-like hairs of a tactile nature. The inner surface is lined with mucous membrane which is smooth and usually of a pink color in the horse. In the ox the middle part of the upper lip is termed the muzzle. It is smooth, cool, and moist in health.

The **cheeks** are two membranous walls which form the sides of the mouth. They are continuous in front with the lips; above and below, with the gums. Numerous secreting glands are found in the substance of the cheeks. In the horse the inner surface is smooth, but in the ox many file-like elevations, termed papillæ, stud it.

The **tongue** extends from the back part of the mouth to the incisor teeth. It is a freely movable muscular organ. Some of its muscles are directed longitudinally, others vertically, and still others transversely. This arrangment affords the organ extensive movements in all directions. A fold of membrane, the frænum, connects the inferior surface with the floor of the mouth. For description, it may be divided into tip, body, and root. The

tip is free and can be extruded from the mouth. The body is the main part and is covered superiorly with many papillæ. Near the back are found large circumvallate papillæ in which the taste-buds are located. The root is inserted into the lingual process of the hyoid bone.

The **teeth** indicate the habits of the animal and serve as organs of prehension, mastication, and as weapons. They are classified according to form and position into: *Incisors*, situated in
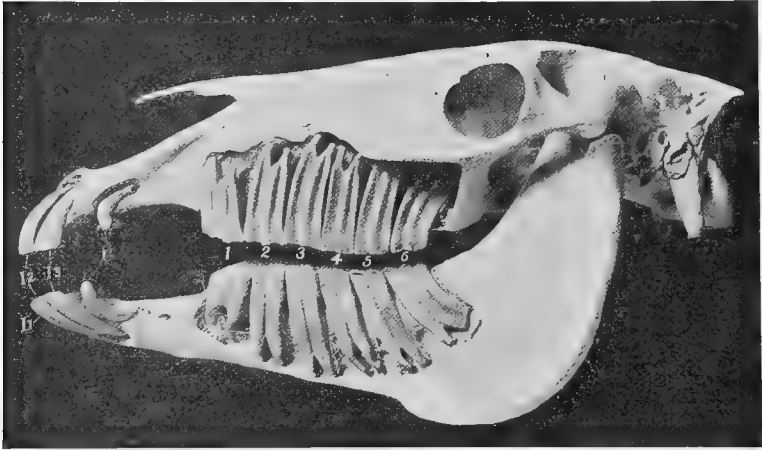

Fig. 16.—Skull of adult horse sculptured to show embedded parts of teeth:1_1, 1_2, 1_3, Incisors; C, canines; 1, 2, 3, 4, 5, 6, molar teeth numbered without reference to the first premolar, which is not present in this specimen. (Sisson, Anatomy of Domestic Animals.)

front, implanted in the premaxillæ and the body of the mandible; *canines*, situated a little further back, nearer the incisors in the lower jaw than in the upper; *molars*, which occupy the side of the dental arch and are often termed cheek teeth or the grinders (Fig. 16). Since the teeth of the two sides are alike, the dental formula has been used as a short method of indicating the number and kind of teeth an animal has. It is represented for adult male horses in the following manner:

$$2\left(I\frac{3}{3}C\frac{1}{1}P\frac{3 \text{ or } 4}{3}M\frac{3}{3}\right) = 40 \text{ or } 42.$$

In this formula the letters indicate the kinds of teeth, and the figures above and below the line give the number of teeth of one side in the upper and lower jaw respectively.

The *dental formula* for the horse varies from the fact that the *wolf teeth*, which are vestigial, may or may not be present. These teeth are classified as upper premolars, but in some subjects occur in the lower jaw. There is still a controversy as to whether they belong to the permanent or temporary set. The presence of wolf teeth does not cause eye disease or weakness, as is popularly supposed.

Anatomically, an incisor tooth is divided into the crown, neck, root, infundibulum, and cup. The *crown* refers to the projecting portion or that part that is visible. The *neck* is the part covered with
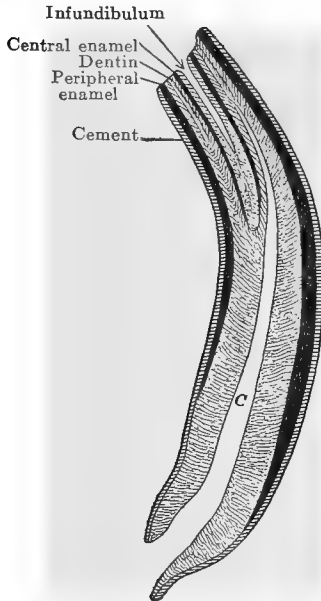

Fig. 17.—Longitudinal section of lower incisor tooth of horse: *C*, Pulp cavity. Cement is shown in the infundibulum, but is not marked. (Sisson, Anatomy of Domestic Animals.)
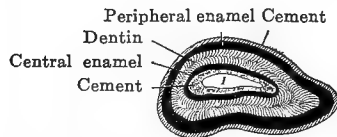

Fig. 18.—Cross-section of lower incisor tooth of horse: *I*, Infundibulum. (Sisson, Anatomy of Domestic Animals.)

the gum. The *root* is the portion that is embedded in the jaw bone. The *infundibulum* is the cavity on the table surface produced by the infolding of the enamel. The *cup* refers to the unfilled portion of the infundibulum of an incisor tooth.

Teeth are composed of dentin, which is capped with enamel and encrusted over the remaining portion with cement (Figs. 17, 18). The *dentin* is dense in consistency, yellowish-white in color, and forms the bulk of most teeth. It surrounds the pulp cavity.

The *enamel* forms a thin ivory-white cap over the dentin of the crown. In herbivora it is folded into the table surface. In the virgin tooth it covers the entire table surface, but soon wears off on the grinding portion, leaving only projecting edges. Enamel is a secretion of epithelial cells and cannot be reproduced when it is once destroyed. It is the hardest tissue of the body. The *cement* is the external covering of the root. In complex teeth, like those of the horse, it fills in spaces between the enamel folds

Fig. 19.—Skull of two-year-old colt, sculptured to show embedded parts of temporary and permanent teeth. The upper first premolar (wolf tooth) is present, but not visible; the lower one is indicated by the arrow. Temporary premolars are numbered 1, 2, 3; permanent premolars are designated by Roman numerals; *Dc*, upper temporary canine; *C*, lower permanent canine, which was not ready to erupt; *Di*2, *Di*3, second and third temporary incisors; *I*₁, first permanent incisor, not quite ready to erupt. (Sisson, Anatomy of Domestic Animals.)

of the crown also and in old horses it increases in amount around the roots of teeth to strengthen them. The alternate arrangement of substances of different degrees of hardness keeps the teeth of herbivora always rough and peculiarly adapts them for the cutting and grinding of coarse vegetable foods.

All farm animals first develop a set of deciduous, temporary or milk teeth, which are smaller, softer, and whiter than the permanent teeth that replace them.

The formula for the temporary or deciduous teeth of both male and female horses is:

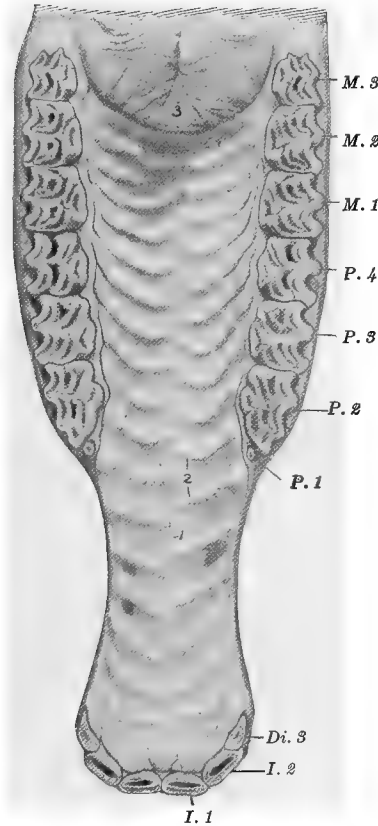$$2\left(Di\,\frac{3}{3}\,Dc\,\frac{0}{0}\,Dp\,\frac{3}{3}\right) = 24$$

FIG. 20.—Upper teeth, hard palate, and adjacent part of soft palate of horse: I.1, First incisor; I.2, second incisor; Di.3, deciduous third incisor; P.1, "wolf tooth" or first premolar; P.2-4, premolars; M.1-3, molars; 1, groove of palate; 2-ridges of palate; 3 soft palate. (Sisson, Anatomy of Domestic Animals.)

As soon as these teeth erupt two influences are at work to destroy them—the permanent teeth are gradually encroaching on their roots, while the crown is becoming short and shorter under the

influence of wear, until at the age of two and one-half years there remains only a loosened shell.

TABLE OF AVERAGE PERIODS OF ERUPTION OF TEETH IN THE HORSE

Teeth	Eruption

A. *Deciduous:*

1st incisor $(Di1)$	Birth or first week.
2d incisor $(Di2)$	4–6 weeks.
3d incisor $(Di3)$	6–9 months.
Canine (Dc)	
1st premolar $(Dp2)$	Birth or first two weeks.
2d premolar $(Dp3)$	
3d premolar $(Dp4)$	

B. *Permanent:*

1st incisor $(I1)$	$2\frac{1}{2}$ years.
2d incisor $(I2)$	$3\frac{1}{2}$ years.
3d incisor $(I3)$	$4\frac{1}{2}$ years.
Canine (C)	4–5 years.
1st premolar (or wolf-tooth) $(P1)$	5–6 months.
2d premolar $(P2)$	$2\frac{1}{2}$ years.
3d premolar $(P3)$	3 years.
4th premolar $(P4)$	4 years.
1st molar $(M1)$	10–12 months.
2d molar $(M2)$	2–$2\frac{1}{2}$ years.
3d molar $(M3)$	$3\frac{1}{2}$–4 years.

(The periods given for $P3$ and 4 refer to the upper teeth; the lower ones may erupt about six months earlier.)

To determine the age of a horse the time of eruption and wear of the teeth are used as guides. In young horses the permanent incisors have a crown which is broad transversely; later in life the two diameters are about equal; in extreme age the antero-posterior diameter may greatly exceed the transverse. The angle at which the upper and lower incisors meet becomes rapidly less as age advances. The cup of an incisor tooth disappears about three years after the tooth erupts, and the infundibulum from ten to fifteen years after. Both central incisors in the lower jaw lose their cups when the horse is about six years of age, the laterals at seven, and the corners at eight. At nine years the cups in the upper central incisors disappear. At ten years a yellowish-brown groove appears at the top of the upper corner incisors, and reaches the wearing surface when the horse is

twenty-one years old. The infundibulum gradually becomes smaller, nearer the lingual border, and finally disappears. It remains longer in the upper than the lower incisors because of its greater depth; therefore the latter should be observed when determining the age of a horse.

FIG. 21.—Skull of ox two years of age, sculptured to show the embedded parts of the teeth: $I1$–4, permanent incisor teeth, the third and fourth not erupted; Di 3, 4, third and fourth deciduous incisors; $P1$–3, upper permanent premolars, only first erupted; Dp 2, 3, deciduous premolars; $M1$–3, molars. (Sisson, Anatomy of Domestic Animals.)

The formula for the permanent teeth of the ox is:

$$2\left(I\,\frac{0}{4}\,C\,\frac{0}{0}\,P\,\frac{3}{3}\,M\,\frac{3}{3}\right) = 32$$

The ox has no incisors in the upper jaw (Fig. 21). There are eight incisors in the lower jaw. They are simple teeth without infundibulum so present no cup. The crown is white, short, and

shovel-shaped. The root is rounded, and is embedded in the jaw in such manner as to allow a small amount of movement. These teeth do not undergo continuous eruption, as in the horse, but gradually wear away so that in old age only mere stubs remain visible. The cheek teeth of the ox resemble those of the horse in number and general arrangement. Wolf teeth seldom occur in this animal.

The deciduous or temporary teeth of the ox are smaller, whiter, and smoother than the permanent set. The dental formula for them is:

$$2\left(Di\,\frac{0}{4}\,Dc\,\frac{0}{0}\,Dp\,\frac{3}{3}\right) = 20$$

TABLE OF AVERAGE PERIODS OF ERUPTION OF TEETH IN THE OX

Teeth	Eruption

A. *Deciduous:*

1st incisor ($Di1$)..........................	
2d incisor ($Di2$)..........................	Birth to 3 weeks.
3d incisor ($Di3$)..........................	
4th incisor ($Di4$)..........................	
1st cheek tooth ($Dp1$)......................	Birth to 3 weeks.
2d cheek tooth ($Dp2$)......................	Birth to few days.
3d cheek tooth ($Dp3$)......................	

B. *Permanent:*

1st incisor ($I1$)............................	$1\frac{1}{2}$–2 years.
2d incisor ($I2$)............................	2–$2\frac{1}{2}$ years.
3d incisor ($I3$)............................	$2\frac{1}{2}$–3 years.
4th incisor ($I4$)............................	$3\frac{1}{2}$–4 years.
1st cheek tooth ($P1$)........................	2–$2\frac{1}{2}$ years.
2d cheek tooth ($P2$)........................	$1\frac{1}{2}$–$2\frac{1}{2}$ years.
3d cheek tooth ($P3$)........................	$2\frac{1}{2}$–3 years.
4th cheek tooth ($M1$)........................	5–6 months.
5th cheek tooth ($M2$)........................	1–$1\frac{1}{2}$ years.
6th cheek tooth ($M3$)........................	2–$2\frac{1}{2}$ years.

The eruption of both sets of teeth is very irregular in the ox due to forced feeding and pampering. The figures in the above table represent the average of observations on a large number of cattle of different breeds.

The **salivary glands** occur in pairs. They are named the parotid, the submaxillary, and the sublingual. The *parotid*

gland is the largest and is located in front of the wing of the atlas, behind the upright portion of the jaw and below the base of the ear. Its length is about 10 inches and thickness nearly 1 inch. Its secretory duct leads from the anterior lower corner of the gland forward and downward, along the inside of the mandible, then it turns outward, around the inferior margin of the jaw, finds its way across the face, and finally ends by piercing the cheek opposite the third upper cheek tooth. The *submaxillary gland* lies internal to the parotid in the submaxillary space. It is about 10 inches long and is curved with the concavity forward. The submaxillary duct is formed by the union of small radicles, and runs forward from the concave border along the floor of the mouth. It empties beneath the tongue opposite the canine tooth. This opening is plainly seen in the living animal, and is commonly referred to as the "barb." The *sublingual gland* is placed between the tongue and the horizontal part of the mandible. In the horse this gland has about thirty sublingual ducts, which open in a row on each side of the floor of the mouth. The function of the salivary glands is to secrete saliva.

The **hard palate** is bounded in front and on each side by the teeth, behind it is continuous with the soft palate (see Fig. 20). On its surface is a median groove dividing it into two equal parts. Twenty curved alternating grooves and ridges run across each half; the concavity of these is backward. The ridges aid in retaining the food when it is carried toward the back part of the mouth. They are sometimes called "wrinkles" or "bars." The ox has a dental pad at the anterior end of the hard palate to take the place of the incisor teeth.

The **soft palate** is a semimuscular organ suspended like a curtain between the mouth and pharynx. It slopes downward and backward from its junction with the hard palate. It presents two surfaces and four borders, and is 5 or 6 inches long in the horse. The anterior surface is toward the mouth, and the posterior toward the pharynx, the anterior wall of which it forms. The lateral borders are attached to the walls of the two cavities which the organ separates. The superior border joins the hard palate, while the inferior is free and in contact with the epiglottis, which may lie either in front of or behind the soft palate. Mucous membrane covers both sides of the organ. During the act of swallowing it is raised to allow the food to pass through. On

account of its length in the horse it is practically impossible for the animal to vomit through the mouth. Instead, the material is passed along the posterior surface of the soft palate and finds exit via the nasal cavity and nostrils. This also explains why breathing does not take place through the mouth.
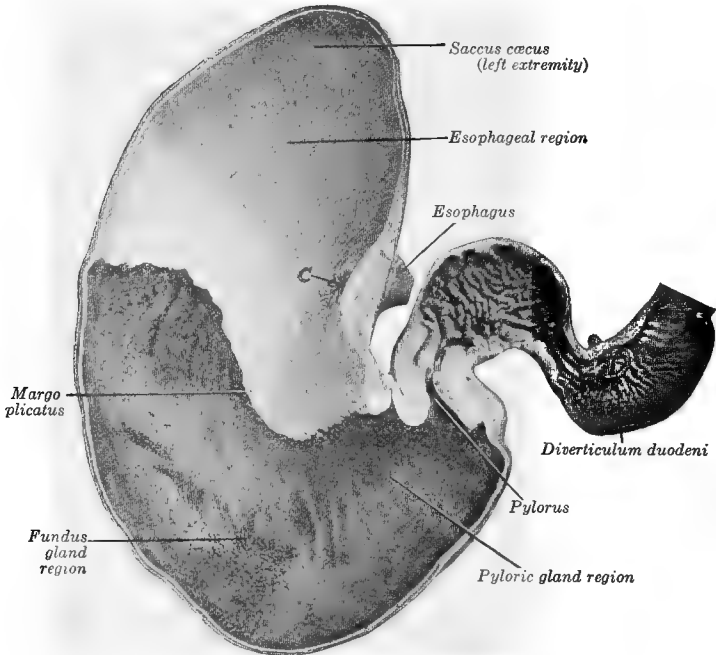

Fig. 22.—Frontal section of stomach and first part of duodenum of horse. The marked difference in the mucous lining of the various gland regions is clearly shown. (Sisson, Anatomy of Domestic Animals.)

The **pharynx** is an organ common to the digestive and respiratory tracts. It is funnel shaped and is situated as a cross-roads between the nasal chambers and the larynx, and the mouth and the esophagus. Its walls are lined with mucous membrane, outside of which are voluntary muscles. There are seven openings in the pharynx—viz.: (1, 2) the posterior nares, which communicate with the nasal chambers; (3) the mouth orifice; (4) the esophagus; (5) the larynx; (6, 7) the eustachian tubes, which

communicate with the middle ear. The latter are slit-like openings, situated high up on the lateral walls of the pharynx, with a cartilaginous flap, which closes during swallowing.

The **esophagus** is a fibromuscular tube which connects the pharynx with the stomach. It is about $4\frac{1}{2}$ feet long and runs down the left side of the neck. Upon reaching the thorax it assumes a median position, passes between the two lungs, pierces
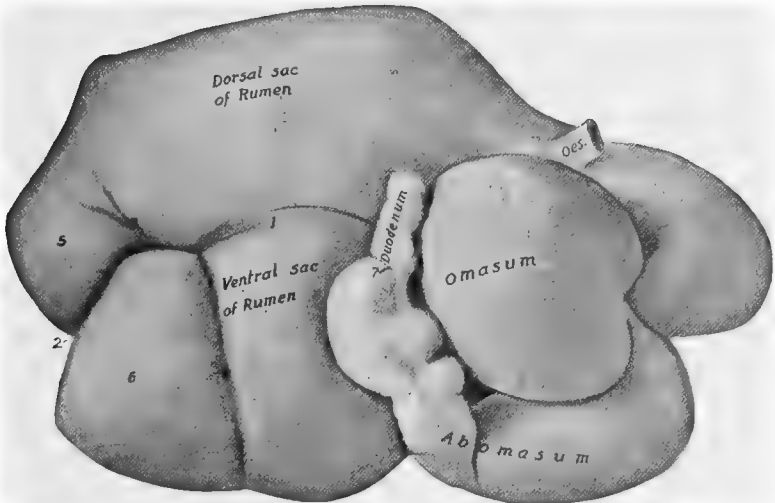
Fig. 23.—Stomach of ox; right view: *Oes.*, esophagus; 1, right longitudinal groove of rumen; 2, posterior groove of rumen; 3, 4, coronary grooves; 5, 6, posterior blind sacs of rumen; 7, pylorus. (Sisson, Anatomy of Domestic Animals.)

the diaphragm, and at once enters the stomach. The lining membrane in the esophagus of the horse is always thrown up in folds except during the act of swallowing. This organ in the ox is about 2 inches in diameter and capable of dilating to a considerable extent.

The **stomach of the horse** is a U-shaped sac located between the esophagus and intestines (Fig. 22). It has a capacity of 2 to 4 gallons. The *inlet* or *cardia* and the *outlet* or *pylorus* are close together. It is situated in the abdominal cavity opposite the fourteenth to sixteenth ribs, behind the diaphragm and liver,

and above the large colon, so it does not come in contact with the walls of the cavity. The stomach is held in position mainly by the pressure of the surrounding organs and by the esophagus. Like other hollow viscera, it has three layers to the wall—the mucous, the muscular, and the serous. The mucous layer is
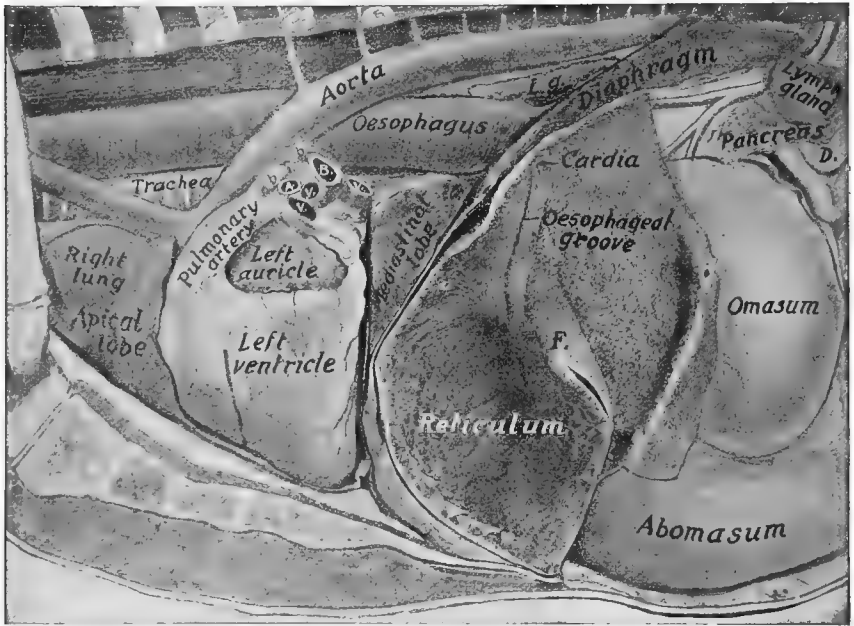
FIG. 24.—Thoracic and anterior abdominal viscera of ox; deep dissection. Most of the rumen has been removed and the left wall of the reticulum cut away. *A.*, Left pulmonary artery; *B.*, left bronchus; *V. V. V.*, pulmonary veins; *b. b.*, bronchial lymph glands; *L.g.*, posterior mediastinal lymph gland; *D.*, termination of duodenum; *F*, rumino-reticular fold. (Sisson, Anatomy of Domestic Animals.)

clearly divided into two parts by the margo plicatus (Fig. 22). That which lies to the left contains no glands, is similar to the lining of the esophagus, and is covered with thick stratified epithelium. The glandular part is subdivided into three zones, according to the types of glands which it contains, but no distinct lines of division exist. The narrow, yellowish-gray zone next to the non-glandular portion contains the short, tubular *cardiac glands*. Next to this lies a large mottled, reddish-

brown area containing the *fundus glands*. The rest of the mucous membrane is reddish-gray in color and contains the *pyloric glands*. The muscular layer is composed of involuntary fibers arranged in longitudinal, circular, and oblique fashion. The serous layer is a reflexion of the peritoneum and is continuous with the great omentum.

The **stomach of the ox** is so large that it fills the entire left half of the abdominal cavity and a part of the right half (Fig. 23). It is compound and consists of four compartments, viz., rumen or paunch, reticulum or honeycomb, omasum or many-plies, and abomasum or true stomach (Fig. 24.) The capacity of the four divisions is 30 to 45 gallons, the rumen constituting about 80 per cent. The lining membrane and arrangement of each division differs in appearance to correspond with the particular kind of work which it has to perform. The interior of the rumen presents long papilla, but has no secretory glands; the reticulum has a honeycomb-like lining; the omasum has about 100 longitudinal folds or leaves; the abomasum has secretory glands like those in the fundus region of the horse's stomach and resembles the

Fig. 25.—Longitudinal section of the small intestine. The submucous coat consists of connective tissue and contains the larger blood-vessels, from which the mucous and muscular coats are supplied with blood. (From Hough and Sedgwick's The Human Mechanism, by permission of Ginn and Company, Publishers.)

stomach of animals having but one compartment.

The **small intestine of the horse** is a tube averaging about $1\frac{1}{2}$ inches in diameter and 75 feet long, originating at the stomach and ending at the cecum. It is arbitrarily divided into the *duodenum*, *jejunum*, and *ileum*. The first part is about three to four feet long and is fixed, while the other parts are floating. It

6

is held in position by the great mesentery. The bulk of the small intestine lies in the upper part of the left flank, but is changeable in 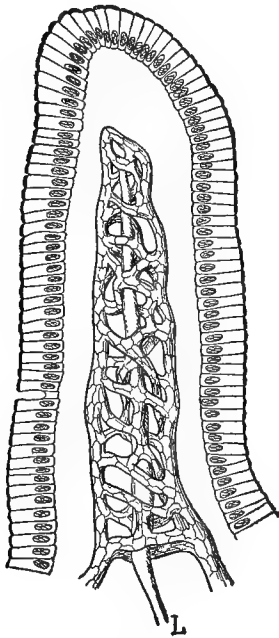situation, depending on the degree of fulness. About 6 inches from the stomach the common opening of the bile and pancreatic ducts pierce the intestine at the diverticulum duodeni (Fig. 22). From the free surface of the mucous lining numerous small projections, termed *villi*, can be seen when a piece of the membrane is placed in water (Fig. 25). Each villus is covered with the cells which line the intestine and contains a network of capillary blood-vessels that surround a central lymph-vessel or lacteal. Food nutrients in water-soluble form are absorbed from the intestine through these lymph and blood channels of the lacteals (Fig. 26).

The **large intestine of the horse** is divided into the cecum, large colon, small colon, and rectum. It is about 25 feet long and nearly twice the diameter of the small intestine. For the most part it is sacculated.

Fig. 26. — Diagrammatic longitudinal section of a villus to show essentials in the structure of a villus. The columnar cells lining the intestine are shown in section. *L*, Lacteal or lymphatic surrounded by a network of capillaries. The connective tissue, which actually exists inside the villus, has been ignored for the sake of simplicity. (Stiles, Nutritional Physiology.)

The **cecum** has a capacity of 7 gallons and is about 3 feet long. It has two blind ends, and resembles in form an inverted comma. The larger end is attached under the right kidney, while the free end lies on the abdominal floor, giving the organ a downward and forward direction. The two openings of the cecum are placed close together in its crook. The opening for the exit of food material being higher up than the inlet, insures a thorough mixing. The latter opening has a valvular arrangement to prevent regurgitation of the ingesta.

The **large colon** is a massive viscus, from 10 to 12 feet long with an average diameter of nearly 10 inches. Its capacity is more than double that of the cecum. It commences at the crook of the cecum and runs downward and forward, along the right costal arch to the sternum, where it curves to the left, and is continued backward on the left part of the abdominal floor to the entrance of the pelvic cavity. From here it doubles back on itself to the place of commencement.

The **small colon** is the sacculated tube which succeeds the large colon and ends at the rectum. It is 10 to 12 feet long and 3 to 4 inches in diameter. It lies coiled in the left flank with the small intestine. It is attached to the sublumbar region by the colic mesentery.

The **rectum** extends from the entrance of the pelvis to the *anus*, the posterior opening of the digestive canal. It is 10 to 12 inches long and is dilated to form a pouch.

The **intestine of the ox** is about twenty times the length of the body. It is coiled in the right half of the abdominal cavity. The small intestine measures about 130 feet in length and is about 2 inches in diameter. The large intestine is of much smaller caliber than that of the horse and is not sacculated. The cecum is about 30 inches long and 5 inches in diameter.

The **liver** is the largest and most important gland in the body (Fig. 27). It is situated in the abdominal cavity just posterior to the diaphragm. It is a dark red-brown color, and weighs about 11 pounds in the average-sized horse and ox. The circumference of the liver is marked by two fissures which divide the gland into three lobes. Pressure from the soft organs and special ligaments hold it in position. The bile duct connects the liver with the small intestine, which it enters about 6 inches from the pylorus, along with the principal pancreatic duct. In most animals a special reservoir for bile is present in the form of the gall-bladder. The horse has no gall-bladder. Besides having the function of manufacturing bile, the liver acts as a storehouse for glycogen, regulates the supply of glucose, forms urea from ammonia, neutralizes toxic products, and eliminates waste hemoglobin and broken down blood cells. These functions have compelled us to look upon this gland as both a secretory and an excretory organ.

The **pancreas** so closely resembles a salivary gland in its struc-

ture and physical properties that it is commonly referred to as the *abdominal salivary gland*. It is situated behind the stomach and largely below the right kidney. There are two ducts in the horse: the larger is the pancreatic duct proper, which has a common opening into the small intestine with the bile-duct; the
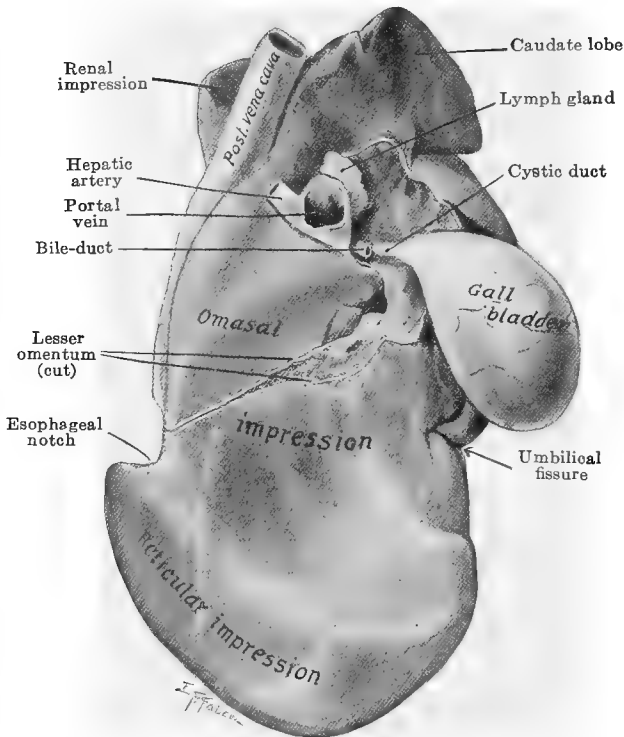

Fig. 27.—Visceral surface of liver of heifer. Specimen hardened *in situ.* (Sisson, Anatomy of Domestic Animals.)

smaller enters on the opposite side by a special opening. The function of the pancreas is to secrete pancreatic juice.

The **intestinal glands** are of two kinds: the glands of Lieberkühn are very small, tubular structures, and are distributed throughout the entire intestinal tract; Brunner's glands are found in the first 20 feet of the bowel. Unless a close examination

is made these glands are not readily seen, as they are embedded in the intestinal walls. The use of their secretions will be mentioned when digestion is studied.

MOVEMENTS OF THE DIGESTIVE ORGANS

It is evident that movements must occur in the alimentary canal to convey the food from organ to organ and mix it with the various digestive juices. With the exception of the movements in the mouth, pharynx, and anterior end of the esophagus, all are carried on by involuntary muscles.

Prehension is the act of taking food and drink into the mouth. In manger feeding the horse uses the lips, but the incisor teeth are brought into play to nip off the grass in grazing. The tongue aids in the prehension of fluids either as a piston during sucking, or as a ladle during lapping. Cattle employ the tongue in grazing; sheep use their lips for this purpose.

Mastication is a voluntary act for the purpose of reducing the larger particles of food to a size suitable to be swallowed and of mixing the food with saliva. The lips, cheeks, and tongue keep the food between the teeth, while the strong muscles that move the jaws are the active agents of mastication. In the horse the movements of the jaws are from side to side and the food is ground between the molar teeth. It is possible for horses to masticate on but one side at a time on account of the upper jaw being wider than the lower. The horse chews his food leisurely, each mouthful being retained for sometime before it is swallowed. Under ordinary conditions it takes him about 1½ hours to eat 6 pounds of dry hay and more than ½ hour to eat the same weight of oats. In the ox the masticatory movements are more complex, the mandible moving transversely, longitudinally, and vertically, besides being rotated to some extent. In the llama the lateral movements are regularly alternated from one side to the other with each contraction of the principal muscles of mastication.

Deglutition, or the act of swallowing, is a complicated reflex movement that is mostly performed independently of the will under a stimulus received from the *swallowing center* situated in the brain. After the food has been masticated it is rolled by the tongue into a sort of ball or bolus. Direct observations by Sisson show that when the horse swallows the following move-

ments occur: The soft palate is shortened and is raised so as to close the openings into the nasal cavity. The pharynx is shortened and its end toward the mouth is dilated. The root of the tongue and the larynx are brought toward each other, so that the epiglottis touches the former. The arytenoid cartilages of the larynx are approximated and the glottis is closed, thus preventing aspiration of food particles. The bolus of food is "shot," so to speak, through the pharynx by an energetic contraction of the muscles which raise the tongue. This is followed by a so-called "clearing up" phase in which remnants that remain are removed from the pharynx by the constrictor muscles of that organ. Fluids are "squirted," through the pharynx. The first stage of deglutition is voluntary, but the rest of the act is not under the control of the will.

The movements of the stomach of the horse are not so extensive or of the "churning" type, as was the opinion before experiments by Ellenberger were carried out. He showed that the stomach of a horse fed in the ordinary manner is never empty and consequently does not have a period of rest as does that of man and the dog. Gastric movements must coincide with gastric digestion, which is a continuous process, but probably they are greater after a full meal. In view of the fact that the pylorus is usually open, it seems apparent that ingesta are continually passing into the intestine.

The rumen of the compound stomach of cattle contracts two or three times per minute. The contractions are stronger and more frequent during feeding, when the ingesta are moved in all directions thoroughly to mix them, and for a period after feeding, when the process of rumination is taking place. They may be felt by pressing with the palm of the hand gently but firmly in the left flank.

Rumination consists of the return of portions of ingesta from the rumen and reticulum to the mouth, where it undergoes thorough mastication and insalivation, and is again swallowed. The process is repeated at intervals of six or eight hours and occupies about one-fourth of the animal's time. It is under the control of the will and usually begins about half an hour after feeding. If a cow that is chewing her cud is suddenly disturbed, the process ceases but can be resumed when she recovers her composure. According to Sisson the mechanism of regurgitation

is quite simple.   The essential factors seem to be: (1) Negative pressure in the thoracic part of the esophagus produced by its relaxation and by the inspiratory phase of the diaphragm; (2) contraction of the rumen and reticulum; (3) contraction of the abdominal muscles.   The result is that a portion of the ingesta in the stomach is injected forcibly into the esophagus and carried to the mouth.   The rôle of the esophagus is largely passive.   As soon as the mass known as the "cud" reaches the mouth, superfluous fluid is squeezed out of it and swallowed.   Mastication begins at once and continues half a minute to a minute, according to the state of the bolus.   The bolus is then swallowed and in three or four seconds another one has reached the mouth.   The "cud" weighs about 100–120 grams.   There is no evidence to support the view that the remasticated bolus when swallowed passes along the esophageal groove to the omasum, although this is a current statement.

In the omasum, or third compartment of the stomach of the ox, the food is thoroughly triturated and reduced to a very fine form.   This is accomplished by pressure between the laminæ and by rasping of the numerous horny papillæ which stud their surfaces.   The contractions of the omasum are slow but very powerful.

The movements of the small intestine are more active than those in other portions of the bowels.   This is evident when an examination is made of the contents, which are found only in small amounts.   As in other organs, a wave of contraction occurs in the muscular coat.   This wave progresses from the anterior to the posterior end of the bowel and is called *peristalsis*.   Simultaneously with a relaxation of the circular fibers in the intestinal walls, the longitudinal fibers contract above the point of relaxation and pull the intestine off the contents as a glove from a finger.   The effects of the process are: (1) Food is repeatedly brought in close contact with different parts of the bowel wall; (2) undigested food is thoroughly mixed with digestive fluids; (3) digested matter is thoroughly exposed to the mucous membrane for absorption; (4) the repeated contractions facilitate the flow of blood and lymph.   When the ear is placed upon the flank of a horse the rumble caused by the passage of ingesta can be distinctly heard.   If the animal is standing quietly the noise can be distinguished at a distance of several feet.   Most physiolo-

gists believe that the efficiency of digestion depends as much upon peristalsis as upon the chemical processes produced by the digestive juices.

The movements of the large intestine are similar to, but slower than, those of the small intestine. There is no good reason to support the idea that material can pass from the small intestine directly into the colon. This supposition was based on the anatomical arrangement of the openings into the cecum. Considerable energy is necessary to move the great masses of ingesta in the large bowel. The energy is furnished by the wide muscular bands in the walls of the viscus. In the horse the feces are molded into the characteristic balls by the contractions of these bands in the small colon.

Defecation is the term applied to the act of emptying the rectum of the undigested and indigestible parts of the food and other wastes. The rectum serves as a pouch for the collection of the feces. When it is sufficiently full a reaction occurs in its walls from pressure, which causes it to be evacuated. The act of defecation is normally involuntary in horses and cattle and is due to the contraction of the smooth muscles in the walls of the rectum. In man fixation of the diaphragm and closure of the glottis are necessary. The sphincter ani muscle forms a purse-string-like protection at the anal opening.

The points that have been covered in the foregoing sections of this chapter show: (1) what structures are concerned with digestion and (2) how they move ingesta. In the succeeding sections we will learn how the processes of secretion, digestion, absorption, and nutrition are concerned with the life of the animal.

THE PHYSIOLOGY OF SECRETION

Secretion is the process of preparing an active substance in solution for use in assisting digestion. In a broad sense it would also include the elaboration of all substances produced by glandular activity, *e.g.*, tears, milk, sweat, and secretions of the ductless glands.

Glands are the organs which produce secretions. They are soft structures composed of secreting tissue supported by a connective-tissue framework that forms a *capsule* and dips into the deeper parts to form *septa*. A typical gland shows on its

surface distinct *lobes* which are subdivided into smaller portions called *lobules*. A *duct* to convey away the product of the gland is usually present. The duct connects internally with the gland *alveoli*, the receptacles into which the secretory cells discharge their fluid. *Blood-vessels* encircle the alveoli and supply lymph to make good the loss caused by the activity of the cells (Fig. 28). Special *secretory nerves* are provided to influence functional activity.

Secretory products are of various kinds and for many different purposes. They are fluid in character and act in a chemical manner. Among the most familiar secretions are the saliva and the gastric juice.

The **process of secretion** is intermittent, periods of rest occurring in the work of glands as in all other organs. During the rest period the protoplasm of gland-cells becomes loaded with small granules that are the stored elements, from which the organic constituents of the secretory product are manufactured. As secretion goes on these granules gradually disappear. If it is continued for some hours, they disappear completely.

If the process of secretion were a mere filtration from the blood through cells into gland alveoli, as was at one time believed, we should expect to find the same amount of soluble, diffusible salts in the secretion as in the blood. Take the saliva as a typical secretion to illustrate the point. It contains only half the

FIG. 28.—The principle of glandular structure. In the upper figure a simple microscopic gland has been laid open by cutting through its vertical axis. The cells are seen to surround a recess, or alveolus, into which they discharge their secretion. Below, the same structure is shown in its entirety, and, in addition, the encircling blood-vessels, which help to make good the loss due to the activity of the secreting cells. (Stiles, Nutritional Physiology.)

amount of diffusible salts as the blood, which makes it clear that the gland-cells must prevent diffusion of the balance. Furthermore, by hindering the outflow of saliva from a duct, the pressure will rise above that of the blood in the blood-vessels which

supply the gland. These facts are conclusive evidence that secretion is an active or vital process carried on by the gland-cells, under the influence of nerves, and is not a simple filtration process in which fluid passes through a filter bed from a higher to a lower pressure. The gland-cells actually determine the amount of salts which shall accompany the water that is secreted.

Another means of proving that the secretory product is manufactured by the gland is to compare the constituents of the secretion with those of the blood which supplies all nutrient and other substances to the gland. Saliva again may be taken as an example. It contains mucus and an enzyme. Neither of these substances is found even in the half-formed state in the blood. The inevitable conclusion is that the gland-cells manufacture the peculiar substances which they secrete. Each gland may accordingly be looked upon as an independent unit. It takes up materials from the lymph and from these manufactures products peculiar to itself. The stimulus which causes a gland to start secreting is received from the central nervous system. In the case of a salivary gland, the message originates from direct stimulation of the sensory nerves in the mouth, or reflexly from the sight or smell of appetizing food. So accurate is the information carried to the glands in the mouth, that when a horse transfers the work of mastication from one side of its mouth to the other, as it is in the habit of doing every fifteen or twenty minutes, the flow of saliva from the parotid gland on the masticating side is increased, while on the other side it is diminished. Often two or three times as much saliva is poured out on one side as on the other. A remarkable control of secretion is seen in the ox during rumination when the submaxillary glands do not secrete, although the other salivary glands are very active.

THE PHYSIOLOGY OF DIGESTION

Digestion is the process of separating the available from the unavailable materials of the food. It consists in dissolving, breaking down, and chemically changing the food so that it can be absorbed and used by the body. Gross digestion is carried on in the digestive canal, but the special preparation of the food for the body cells is carried on in the protoplasm of the cells themselves.

Factors influencing gross digestion are of several kinds. Those of most importance are:

The Quality of the Ration.—Coarse, woody feeds like corn stalks, overripe hay, straw, etc.; containing much cellulose are difficult to digest. If they are cut with a feed cutter before being fed, they are more easily and completely digested. Rations of any kind that are poor in quality are unpalatable and retard digestion. Some feeds have a constipating effect, *e.g.*, cottonseed meal, while others have a laxative effect, *e.g.*, linseed meal.

The Quantity of the Ration.—Too much feed of any kind hinders the digestive process. It is believed, however, that with herbivorous animals a fairly bulky grain ration gives better results than one occupying less space. This is true in less degree of roughages.

Variety in the Ration.—If feeds are mixed before feeding according to determined standards, they are more palatable and the work of the digestive organs is distributed and digestion facilitated. An exclusive ration of any kind is not so readily digested, especially if fed over a long period, as one properly mixed and balanced. There is evidence that some kinds of feed influence the digestibility of others.

The Completeness of Mastication.—Incomplete mastication from any cause results in the introduction of too large food particles to the stomach and hinders digestion. The more perfectly foods are masticated the greater the amount of nourishment afforded the animal, because less energy is expended to digest them. Therefore, the longer it takes an animal to eat a meal of dry feed, the more economically can it be kept. Various devices or automatic feed controllers are in use to compel horses to eat more slowly, but none has proved to be entirely satisfactory. A few cobblestones placed in the bottom of the feed manger tend to prevent bolting of food.

The Idiosyncrasy of the Animal.—This refers to the disposition of the individual. Some animals are much more efficient machines for converting the stored energy in their rations into free energy than others. This is one reason why certain animals are "easy keepers," while others are "hard keepers" and fail to thrive even under good living conditions. The factors involved are of a physiologic nature. An examination of the composition of the excreta of different animals of the same breed

and kept under identical conditions also shows that digestion is more complete in some than in others.

(A) **Digestion in the Mouth.**—The first digestive change that food undergoes occurs in the mouth. It is a chemical change and is due to the secretion known as saliva.

Saliva plays a very important rôle in the digestive process, especially through its water, which lubricates the food for mastication and swallowing. It is a fluid of alkaline or neutral reaction and turbid and slimy appearance, which deposits a white precipitate on standing.

The amount of saliva secreted by a horse in twenty-four hours has been estimated at 72 to 84 pounds, but will depend on the dryness of the food consumed. This is nearly ten times as much as the volume of urine voided during the same peiod. A feed of 6 pounds of dry hay has been found to increase during mastication to 24 pounds or to add four times its weight of saliva. Colin places the daily secretion of saliva in the ox at 112 pounds. Man secretes between 2 and 4 pounds daily.

As all students in agricultural colleges have an opportunity to study Feeds and Feeding it is to be presumed that they are familiar with the composition and significance of the food of animals and their requirements under different conditions. However, it is advisable to call attention to the general composition of foodstuffs, viz.: (I) the inorganic compounds—water and mineral substances; (II) the organic compounds—proteins and albuminoids, which are body-building foods; and fats and carbohydrates, which are principally fuel foods that supply work and heat energy. The food constituents and the constituents of the animal body mentioned in Chapter I should also be compared.

The composition of saliva varies with the character of the substance in the mouth which has excited it to flow. Coarse sand or irritating chemicals cause a flow of very watery saliva to wash the irritant away; water excites the flow of a very viscid saliva rich in mucin. The inorganic constituents are water to the amount of 99 per cent., and phosphates, chlorids, and sulphates of sodium, potassium, calcium, and magnesium. The organic constituents are mucin and the enzyme ptyalin. The water and salts are derived directly from the blood, while the mucin and ptyalin are manufactured by the gland-cells.

Mucin is found in very small amount in the saliva of the horse. In that of man and certain other animals it is present in larger amount.

Ptyalin acts on starch, dextrin, and other carbohydrates, converting them into simpler bodies. The first change is a conversion of the huge starch molecule into dextrin and then into maltose. Like other enzymes, pytaline[1] is not destroyed or used up in producing its reaction, but if heated to 60°C. it loses its power. It is most active in a neutral medium at the body temperature. In the presence of the free hydrochloric acid of the stomach ptyalin is rapidly rendered inert. The chief part of salivary digestion actually occurs in the stomach despite the hydrochloric acid of the gastric juice, which requires some time to penetrate the food. This is due to the low motility of the cardiac portion of the stomach, which prevents the food from mixing with the hydrochloric acid very promptly, and to the fact that this secretion is confined to the fundus and pyloric regions. It would seem fitting, on account of the large amount of carbohydrates in his food, that the horse's saliva contain a large amount of ptyalin, but examination shows that saliva taken from the parotid duct is unable to convert a starch mixture into a reducing sugar except in a very limited extent and after a considerable time.

(B) **Digestion in the Stomach.**—The stomach is popularly supposed to be the chief organ of digestion. While this may be true in man, in the horse and in the ox the stomach acts principally as a temporary storehouse for food, which is undergoing preparation for the more complex digestive changes designed to take place in the intestines.

Gastric juice is secreted by the glands of the stomach. The difficulty of obtaining a pure sample from the horse and ox has prevented detailed study of the secretion from these animals. The physiologically important constituents are lactic and hydrochloric acids, water, and the enzymes, pepsin and rennin. Fresh gastric juice also contains much mucin, but this has only a passive part in digestion. It forms a thick, viscid covering for the food shortly after it is introduced into the stomach.

Lactic and hydrochloric acids are found free in the gastric juice and give the secretion an acid reaction. By inhibiting

---

[1] To show the presence and action of ptyalin, some starch paste should be prepared. Five c.c. of the paste may be placed in each of as many test-tubes and filtered saliva added in different quantities. By keeping them at various temperatures and testing from time to time with iodin and Fehling's solutions the progress of digestion in the mouth may be well demonstrated.

the growth of all kinds of bacteria they act as antiseptics, thus preventing excessive fermentation and putrefaction. The percentage of hydrochloric acid is considerably lower in herbivora than in carnivora, therefore micro-organisms are not so readily destroyed, and have a longer opportunity to act on the sugars resulting from digestion of the carbohydrates. On a diet of starchy food the lactic acid always exceeds the hydrochloric acid, suggesting it may be due, in part at least, to the fermentation of the carbohydrates.

The rate of emptying the stomach is controlled in a measure by these acids, but not to such an extent as in the dog, for the pylorus of the horse generally is open. Furthermore, while the acidified protein in the stomach causes the pyloric sphincter to relax, in the intestine it causes it to contract and close. Thus an alternate opening and closing of this valve occurs. The semi-fluid material is squirted through the pylorus; in some animals the noise is audible.

Many chemical theories have been advanced to explain the production of hydrochloric acid. One is based on the fact that during the process of digestion in both the stomach and intestines a large amount of CO_2 is formed from fermentation of carbohydrates. This is absorbed[1] into the circulation as is that from tissue oxidation. It is thought that this CO_2 decomposes the NaCl of the blood and produces Na_2CO_3 and free HCl. The origin of the latter in the stomach is thus accounted for. The sodium carbonate is finally excreted in the urine or goes to form bone.

Schattke found an acid reaction in all parts of the horse's stomach ninety minutes after feeding; previous to that time the esophageal portion gave an alkaline or neutral reaction due to the saliva.

Water is secreted by the gastric glands. Its production varies with the dryness of the food. When the stomach ingesta are ready for passage into the intestine they contain a surprisingly

---

[1] This explanation is not entirely satisfactory as it neither shows why HCl is not eliminated by the kidneys nor why Na_2CO_3 is not found in the gastric juice. Furthermore, McCollum has found that in the bodies of pigs under experimental conditions, decomposition of the sodium chloride molecule and formation of hydrochloric acid does not occur. Therefore, it is probable that the process of HCl production is due to vital action.

constant amount of water. If dry food is eaten, more water is secreted to make up the deficiency. On the contrary, if too much water is present, it is passed on to the intestines before gastric digestion is completed. This indicates that the secretions of acid, pepsin, and water by the stomach glands are independent of each other.

Pepsin acts principally on the highly organized protein molecules, converting them into peptones. This conversion is a very complex process and is accompanied by hydration. Pepsin is active only on acidified protein. The presence of the latter stimulates the glands of the stomach to activity.

Rennin has the power of curdling milk. It acts upon the caseinogen of milk and splits it into a proteose-like body and soluble casein. The latter combines with calcium to form insoluble casein. Hammarsten says that some rennin is found in the adult horse's stomach. Probably the foal's stomach secretes much larger quantities.

The flow of gastric juice commences before food reaches the stomach, in fact the mere sight or smell of appetizing food starts action in the glands of the stomach. When food enters the mouth and the nerves of taste are stimulated, the secretion becomes even more pronounced. It keeps up until the entire mass of food in the stomach has undergone gastric digestion—a period of about three hours in the horse.

When horses are fed different kinds of foods in succession, it has been found, by killing them at varying intervals after feeding, that the first food taken passes into the most ventral part of the stomach. Subsequently, ingested food is arranged in layers, provided its consistency is sufficient to hold it from forming a mechanical mixture with previously ingested materials (Fig. 29).

There is some difference of opinion in regard to the effect of watering a horse after feeding. It is evident that when a horse which has eaten an ordinary feed drinks any great quantity of water, both cannot be accommodated in the stomach. Scheunert and Schattke[1] conclude, from a series of experiments which they carried out: (1) That the drinking of water in any amount desired by the animal exerted no deleterious effect on digestion. (2) That the increase in the water content of the ingesta was in-

[1] Cited by Sisson.

considerable, reaching at most 10 per cent. above the normal average; a similar increase can be produced by the large amount of saliva secreted during mastication of hay or by exercise. The interval before return to the usual lower water content varies individually; in one case it was only ten minutes in duration, but in general appears to be one or two hours. (3) The bulk of the water leaves the stomach quickly. When the stomach is well filled, the contents are only penetrated very superficially by the water.
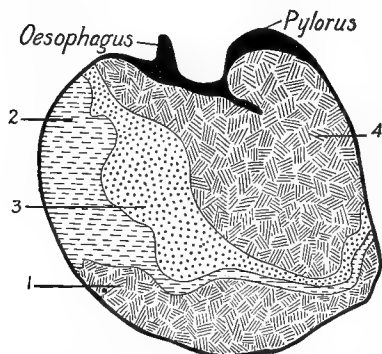
FIG. 29.—Longitudinal section of stomach and contents to show how food is distributed in the stomach. The horse was fed, in turn, (1) 500 grams hay; (2) 750 grams uncolored oats; (3) 750 grams colored oats; (4) 500 grams hay.

Digestion of hay by the horse was found by Colin to be facilitated when water was allowed with or shortly after feeding. According to Ellenberger in order for the horse to obtain the fullest possible nutriment from his ration, hay should be fed first, then water, and finally the grain. This practice differs from that usually followed in this country, but is in keeping with the facts already mentioned relative to the mechanism of the stomach.

On account of the limited capacity of the horse's stomach, only a portion of a meal can be accommodated at one time. When he is allowed to eat continuously, some food must pass on to the intestines before stomach digestion has been completed. This may result in digestive disturbances of various kinds, especially colic.

Another interesting point in regard to stomach digestion is that here starch is converted into sugar, in those animals whose saliva is deficient in ptyalin, by a starch-splitting enzyme that is present in all the small grains high in starch. This fact makes it apparent that grain should not be cooked before being fed.

Proteins are largely digested in the stomach and small intestine. The process of breaking them down is known as putrefaction. It results in the formation of various sharp-smelling

waste products, viz., hydrogen sulphide, ammonia, indol, and skatol; and in various highly important nutrients, viz., several different amino-acids concerning which more will be said later. In some animals finely emulsified fat is split in the stomach but most fat is digested in the intestines.

At present our knowledge of the bovine stomach leads to the conclusion that all or almost all of the fluid swallowed passes to the rumen and not directly to the omasum, or third compartment, as was at one time believed. This statement is based upon the results of experiments in which the drinking water of cattle was colored with magenta and the animals were slaughtered at the end of several hours.

In the paunch of cattle more than half of the cellulose is broken down. This results in the production of large quantities of gas, particularly CO_2, H_2, and CH_4, which the animal belches at frequent intervals. The factors concerned in this process will be mentioned later.

(C) **Digestion in the Small Intestine.**—During the process of stomach digestion that portion of the ingesta which has been acted upon by the gastric juice gradually feed into the small intestine.

Chyme is a watery solution of the products of gastric digestion with a large quantity of undissolved, semi-digested matter in suspension. It is soup-like in consistency, and contains most of the fibrous parts of the diet, particularly cellulose. Shortly after reaching the small intestine the acid chyme is neutralized and then becomes alkaline from having been mixed with the biliary, pancreatic, and intestinal secretions. These alkaline digestive juices cause the acid albumin to precipitate which changes the appearance of the chyme to a yellowish, frothy fluid with clot-like particles held in suspension.

Bile is secreted by the liver, from which it is conveyed to the small intestine by the bile-duct. As the horse has no gall-bladder, the flow of bile is continuous, but is much freer when intestinal digestion is going on than in a fasting animal. In other animals the bile is stored in the gall-bladder until required.

A physical examination of bile shows that it is a watery fluid, alkaline in reaction, and very bitter to the taste. Fresh bile is yellowish-green in color, and has an average specific gravity of 1005. According to Colin, from 250 to 310 c.c. of bile are secreted

7

by the horse per hour. The principal constituents are water about 92 per cent., the salts of the bile acids, biliary pigments, and the waste products lecithin and cholesterol.

The *salts of the bile acids* are sodium glycocholate and taurocholate. The former is found in larger quantities in herbivora. These salts precipitate proteins of the ingesta thus delaying their passage and giving the digestive juices more time to act. They prepare fats for emulsification and favor their absorption.

The *bile-pigments* are bilirubin and biliverdin. The first is apparently derived from the blood-pigment. Biliverdin is produced from bilirubin by oxidation, and gives the bile its characteristic color.

Although bile acts on proteins in a limited way, its chief functions are to dissolve and emulsify fats. It is most active in the presence of pancreatic juice. However, bile is so unimportant that intestinal digestion can proceed without its presence.

Pancreatic juice reaches the intestine of the horse by two separate and distinct ducts, as already described. The ox has but one duct for this product. The secretion is indirectly stimulated to production by the presence of the acid chyme from the stomach, which acts on a product of the epithelial cells of the duodenum known as *prosecretin*, changing it into *secretin*. When secretin is absorbed by the blood and reaches the pancreas, it stimulates this gland to secrete the pancreatic juice. It also acts on the liver, causing that gland to secrete bile. Secretin is not an enzyme, for it is not destroyed by heat. It cannot be synthetized; in fact, little is known about its properties. To date no substitute has been found. The presence and action of secretin was first demonstrated by Bayliss and Starling who injected into the circulation an extract made by washing scrapings from the intestinal mucosa with weak hydrochloric acid.

The average daily secretion of pancreatic juice by the ox is 3 to 4 pounds. It is strongly alkaline in reaction, due to sodium carbonate, and has a specific gravity of about 1010. The important constituents are three enzymes—trypsin, amylopsin, and steapsin.

Trypsin is the most important pancreatic enzyme. It is secreted in pro-enzymic form as *trypsinogen*, but is at once activated by the enterokinase of the intestinal juice. It has the power to change proteins into proteoses, peptones, and many

other comparatively simple products of protein digestion. *Amylopsin*, or *diastase*, acts on the starchy constituents of the food in much the same way as does the ptyalin of the saliva, converting them into dextrins and sugars. *Steapsin*, or *lipase*, derives its name from the fact that it splits the fats by hydrolysis into glycerin and their fatty acids. These fatty acids combine with the alkaline salts to form a soapy emulsion (Fig. 30).
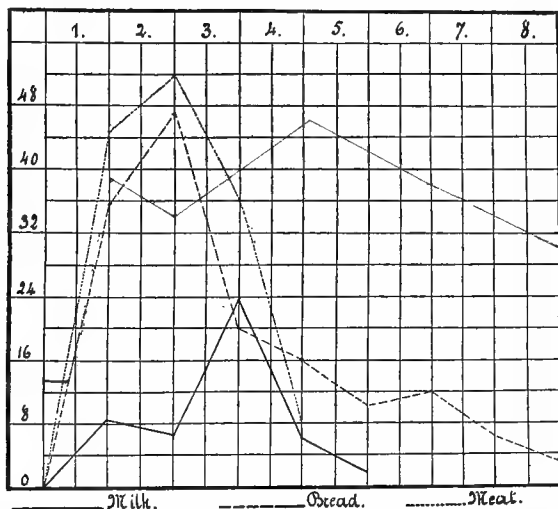
FIG. 30.—Four curves of the secretion of the pancreatic juice, the three in black, from Walter, showing the secretion in dogs on different diets: (1) on 600 c.c. of milk; (2) on 250 grams bread; (3) on 100 grams of meat. The curve in red, from Glaessner, shows the secretion in man on a mixed diet, soup, meat, and bread. The figures, 1, 2, 3, etc., along the abscissa indicate hours after the beginning of the meal. The figures along the ordinates indicate the quantity of the secretion in cubic centimeters. (Howell's Physiology.)

Intestinal juice is secreted by the glands in the intestinal walls, so has been termed *succus entericus*. It is a light yellow fluid, alkaline in reaction, and contains several enzymes of much importance to the welfare of the animal. These enzymes include *erepsin*, which is the last agent to act on the products of protein digestion and to prepare them for absorption; *diastase*, which converts starch into maltose; *invertase*, which has the power to invert dextrose, maltose, and lactose into the simpler glucose—

the form in which all carbohydrates must be converted for absorption; *enterokinase*, which converts trypsinogen into trypsin. Another important constituent is carbonate of soda, which neutralizes further the acid chyme thereby preparing it for absorption.

(D) **Digestion in the Large Intestine.**—From the small intestine the ingesta pass into the cecum, where they may remain from twenty-four to thirty-six hours in most animals. The cecum is undoubtedly a most important digestive organ in the horse because of its large size and the length of time food remains in it. It always contains considerable ingesta mixed with much water. Ellenberger has called the cecum the second stomach, in which maceration, fermentation, and decomposition changes occur in the food to fit it for absorption.

The chief constituent of the roughage in horse feed is cellulose. Cellulose forms the skeleton of plants, and is present as undigested particles in the contents of the cecum and colon. On account of its resistant character, it escapes digestion both in the stomach and small intestine of the horse. In the large intestine, however, its destruction is brought about by the myriads of bacteria which thrive in the warm, moist, anaerobic conditions that there prevail.[1] In ruminants this process takes place largely in the stomach.

Most of the microörganisms that act on cellulose are anaerobic. They break down the resistant vegetable cells and the cellulose disappears. Just what, if any, part is played by the digestive enzymes in cellulose digestion is a mooted question.

[1] Cellulose destruction by bacteria can be well demonstrated by placing strips of filter-paper in a solution composed of

Dibasic potassium phosphate	1.0 gram.
Magnesium sulphate	0.5 gram.
Ammonium sulphate	1.0 gram.
Calcium carbonate	5.0 grams.
Water	1000.0 grams.

A large test-tube should be filled two-thirds with this solution, and 2 grams of horse feces together with two strips of filter-paper added. To exclude air and closely approximate conditions found in the intestines a layer of paraffin oil ½ inch deep must be poured over the surface of the mixture. Then incubate the tube at 37°C., until signs of decomposition appear and test for starch, sugar, carbon monoxide, carbon dioxide, free hydrogen, and marsh gas.

It seems doubtful whether they exert any action, for when cellulose is broken down not the slightest trace of sugar can be found, but large amounts of carbon are liberated. It is thought that the carbon combines with hydrogen to form methane, and with oxygen to form carbon dioxid. The expired air contains these gases in relatively large quantities, which has led physiologists to think that, in the horse at least, we can account for their presence in large measure by cellulose destruction. There is reason to believe that the more resistant cellulose-containing portions of the food are not transformed until they have been acted upon by the various agents noted above and reach the last portion of the large colon. On the strength of these facts, it seems unreasonable to attribute much energy value to cellulose destruction. The process may be considered simply an accident in the course of digestion.

Some of the aerobic microörganisms found in the bowels have a lipolytic action, *i.e.*, the power of splitting fat. So have the juices of certain molds. The seeds of certain plants high in oil also contain a lipase that is liberated on germination and when their capsules are destroyed in the course of the digestive process.

Armsby says that the horse is unable to digest more than 30 per cent. of the combustible materials in roughage. Ruminants are more economical feeders, digesting about 40 per cent. In the case of concentrates about 80 per cent. are digested by ruminants and 60 per cent. by the horse.

Immediately after passing into the small colon a very marked change occurs in the character of the intestinal contents; from a greenish-brown pea-soup-like fluid it becomes firmer and resembles quite closely fresh feces. As the material is moved on toward the rectum it gets drier and is molded into characteristic forms through the action of the muscular bands in the walls of the small colon. Smith states that the reaction is still alkaline or neutral at this point, but after reaching the rectum a distinctly acid reaction is noted on the surface of the feces.

Feces represent the residue of digestion. In the horse they have a characteristic earthy odor due to indol, skatol, and hydrogen sulphide. When digestive disturbances are present they become extremely offensive. Fresh horse feces contain about 74 per cent. water, 23 per cent. organic matter, and 3 per cent. inorganic matter. The water varies with the character of the feed,

being more plentiful when grass and other succulent feed comprise a large part of the ration, than when dry feeds are consumed. Cattle eliminate about 56 per cent. of the water drunk in the feces. The organic matter consists of waste products of glandular secretions such as bile pigments, cholesterin, and mucus; great numbers of bacteria; the woody parts of the roughage; proteins that escape digestion, and the residue from protein metabolism. The inorganic salts of sodium, calcium, potassium, magnesium, and iron are found in different amounts. Both sodium and potassium are in comparatively insoluble forms.

A thin coating of mucus covers the feces and gives them a shiny appearance. Smith observed that horses on a diet consisting of 12 pounds of hay, 6 pounds of oats, and 3 pounds of bran passed 29 pounds 13 ounces of feces in twenty-four hours. It takes about four days for food to pass through the alimentary tract of the horse, but solid bodies have been found in the feces after twenty-four hours.

Meconium is the fecal material found in the intestines of the fetus. It consists largely of waste products from the liver. The first milk (colostrum) contains substances which hasten bowel action and cause the meconium to be expelled soon after birth.

The essential points mentioned in connection with digestion may be summarized as follows: Digestion involves a reduction of foods to relatively simple, water-soluble forms. Most of the carbohydrates are changed to sugars by the action of starch-splitting enzymes, the fats to fatty acids and glycerin, and the proteins to amino-acids.

THE PHYSIOLOGY OF ABSORPTION

Absorption is the process of taking up the materials in solution which have been prepared and modified by the secretions during digestion.

The cells of the intestinal wall are the active agents that select prepared nutrients from the ingesta, while the blood and lymph act as transporters of these substances to all parts of the body. The process of absorption resembles secretion in that it is not a simple diffusion or osmosis of fluids operating under physical forces, but is due to the selective action of the living epithelial cells which cover the intestinal villi. It differs from secretion in that fluids are taken up instead of being poured out. To

understand the mechanism of intestinal absorption the diagram of a villus (Fig. 26) should be carefully studied.   A mechanical factor of importance in absorption is the rhythmic increase in pressure in the intestines due to the contraction of the diaphragm with each inspiration.

The extent to which absorption takes place in the stomach of the horse is not positively known, but is limited to water and water-soluble substances in small amounts.   Easily diffusible substances like alcohol and ether are readily absorbed.   Colin conducted a series of experiments to determine the part played by the stomach in absorption.   He ligated the pylorus and then placing strychnine in the stomach found that no matter how long it was left there poisoning did not occur; but when the ligature was removed and the chyme was allowed to pass into the intestines, symptoms of strychnine poisoning rapidly appeared. On the strength of this work and from lack of more conclusive evidence it may be assumed that practically no absorption takes place from the stomach of the horse, or if it does, the process must be extremely slow.

The greatest amount of absorption is through the millions of minute villi that stud the small intestine.   The process is more pronounced here than in the large intestine, not because the ingesta remain longer, but because of the greater length of this part of the canal.   The experiment of Colin in which he injected hydrocyanic acid into the small intestines of a horse and caused death in less than one and one-half minutes proves that intestinal absorption is very rapid.

Absorption is complicated from the fact that there are two paths by which the materials of digestion may enter the general circulation; these are: (1) the numerous small veins which collect the blood from the stomach and intestines; (2) the lacteal vessels which collect the fluid absorbed by the lacteals of the intestines.

The very large portal vein (Fig. 27) is formed by the confluence of the small veins just mentioned.   It discharges its flow into the liver.   This organ is most advantageously situated between the digestive and circulatory systems (Fig. 31).   It performs the highly important work of separating the nutrient from the poisonous substances in the portal blood.   This function of the liver may be shown by connecting the portal vein of an experimental animal with the posterior vena cava so that the portal blood will

flow at once into the general circulation.   Death from auto-intoxication will shortly follow.

The lacteal vessels run between the folds of mesenteries and empty their contents into the receptaculum chyli.   This reservoir is drained by the thoracic duct, which in turn empties into one of the large veins that discharges its flow into the right auricle (see Figs. 26 and 31).   There are lymph glands, on the course of the lacteals in the mesenteries, through which the chyle is filtered and by which any foreign particles that may have been absorbed from the intestines are removed.
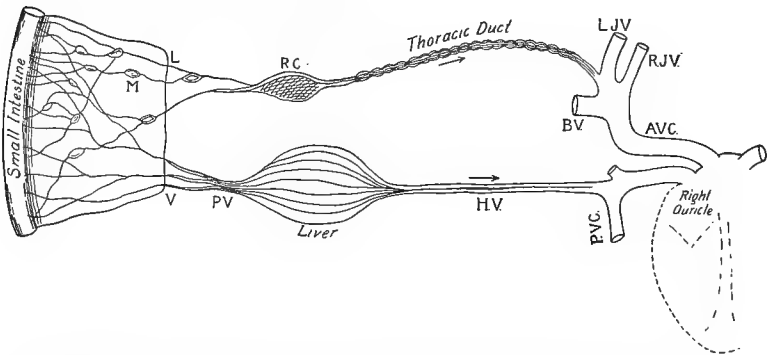
Fig. 31.—Diagrammatic representation of the two paths of absorption: V., Veins of the mesentery which unite to form the portal vein, P.V.; H.V., hepatic vein; P.V.C., posterior vena cava; L., lacteals which convey through mesenteric lymph-glands, M., to the receptaculum chyli, R.C.; L.J.V., left jugular vein; R.J.V., right jugular vein; B.V., brachial vein; A.V.C., anterior vena cava.

I. **Materials Absorbed by the Blood-vessels.**—These are of various kinds and may be divided into two groups, viz., those that are of use to the body and those that are harmful to the body.   The first group is composed of amino-acids, glucose, water, and mineral substances.   The second group consists of ammonia and certain other toxic materials.

Amino-acids comprise a number of organic substances, among which are aspartic acid, arginin, cystin, histidin, leucin, lysin, phenylamin, prolin, tryptophan, and tyrosin.   When any one of these is lacking in the ration, starvation will result.   They represent the last stage in protein digestion; further cleavage would probably render the nutrients unsuitable for use by the

body. The amino-acids pass through the liver unchanged and go to the muscles and other tissues of the body where they appear to be synthetized into such body-proteins as are found in muscle and ligamentous tissue, or otherwise made available as a source of energy and growth for the body. At one time it was believed that the proteins were broken down only so far as proteoses and peptones, in which forms they were absorbed. Now we know that there is a further cleavage, for not only is it impossible to find even traces of these substances in the blood of animals fed on a very high protein diet, but by injecting purified proteose and peptone into the blood-stream of experimental animals death occurs at once, due to the toxicity of these substances. The theory at present most generally accepted is that protein substances are absorbed as amino-acids; the final conversion being the result of the action of the enzyme erepsin.

Glucose is the form in which carbohydrate materials are absorbed by the blood. When glucose reaches the liver it is believed that a part immediately passes through this organ unchanged. The balance is converted into glycogen and stored for future use. The fact that the muscles also have the ability to convert glucose and store it as glycogen should be recalled. More complex forms of sugar, for example maltose, cannot be made use of by the organism without being inverted. This is shown by injecting maltose subcutaneously, in which event it is excreted unchanged in the urine.

The issue of sugar from the liver is surprisingly constant no matter how much is being supplied to it by the blood collected from the intestines. The means by which the output is controlled is not fully known. It is surmised that an internal secretion or hormone produced by the pancreas and carried to the liver by the blood is the influential factor, for when the pancreas is removed experimentally the urine is soon found to contain sugar. While glucose is ordinarily absorbed in very large amounts, complete removal of carbohydrates from the ration does not result in death as is the case in removal of proteins.

Water is absorbed in part by the blood-vessels, the process being very rapid if there is a deficiency in the tissues. There is difference of opinion as to the mechanism of water absorption from the small intestine. Some authorities consider it is brought about by diffusion, osmosis, filtration, and other physical proc-

esses; others believe that although these processes are operative, the controlling factor lies in the vital action of the epithelial cells in the intestinal walls.

Mineral substances are absorbed from the intestines by the blood in proportion to the requirements of the body.

Ammonia is formed, according to Folin, in the large intestine as a result of putrefaction of the residue of protein digestion. It is absorbed by the blood and carried to the liver where it is largely disposed of by combining with hydrogen to form *urea*, the chief waste substance excreted in the urine. When ammonia or urea accumulate they irritate the tissues and interfere with their work.

Toxic materials are absorbed in considerable amounts from the intestines by the blood. Upon reaching the liver they are destroyed or rendered harmless by being dissolved, oxidized, or precipitated. This important function of the organ was clearly demonstrated by Schiff, who injected a dose of nicotine through a peripheral vein and caused death, while the same dose introduced into the portal vein was without effect.

II. **Materials Absorbed by the Lacteals.**—These consist of products of fat digestion and water. They form an emulsion called *chyle* which is emptied into the receptaculum chyli. Chyle is moved forward by the rhythmical contractions of the muscles in the walls of the intestines and villi. It is prevented from returning by valves in the lacteals.

Fat is not absorbed until it is converted into fatty acid and glycerin by the action of the digestive juices. As neither of these is found free in the blood, the living epithelial cells in the villi must synthetize or reconvert these substances into a neutral fat. Shortly after chyle is poured into the blood its fat disappears, having been taken up by the cells of the body for their use.

Water is taken up by the lacteals and forms the transporting medium for the products of fat digestion.

The order in which the various food nutrients mentioned above are drawn upon for the production of energy under ordinary conditions is as follows: first the available glucose is used, then the fats are oxidized, and finally the amino-acids are made use of by the body cells.

THE PHYSIOLOGY OF NUTRITION

Nutrition is the process of assimilating or transforming food into living tissue. It has been called constructive metabolism or tissue building. A feeder of animals without a knowledge of the principles of animal nutrition is unable intelligently to feed his live stock.

Not until very recently has much progress been made in the study of animal nutrition. This was due to the fact that no method had been found by which it was possible to control experimental animals and their rations. In 1906 Dr. E. V. McCollum, who was then connected with the Wisconsin College of Agriculture, started investigations designed to show more clearly just how rations of different kinds affected nutrition. He experimented largely with rats but used hogs and cattle when advisable.

One of the first important things that scientists discovered in the study of nutrition was that purified foodstuffs containing all the supposedly essential substances for nutrition, viz., proteins, carbohydrates, fats, water and salt mixtures, when fed experimental animals not only do not induce growth, but also fail to sustain life for any great length of time, not over two months.

In his experiments McCollum found that the addition of a small amount of egg yolk or dried milk to the above mentioned purified mixture caused animals to grow satisfactorily. Also that the addition of wheat, corn, or even meat was unable to make the animals grow or maintain them in a healthy condition. Furthermore, when all the fat was extracted from the egg yolk or dried milk, the residue would not make the animals grow. However, when the egg fat or butter-fat was replaced in the purified ration, the ration became complete again.

The next surprising discovery was that with the fats of the egg yolk as the only addition to the purified foodstuffs, the animals would not grow. But by adding a little of the egg yolk, which is not fat, and leaving in the egg fats, growth at once started.

This led to carrying out an experiment in which to a mixture of the pure food was added the egg yolk fats, and instead of all that part of the egg yolk that was left after extracting the fat, only those substances that are water soluble were added. This ration caused growth just as if the whole yolk were in the food.

Before McCollum had completed the investigations just men-

tioned, other investigators had announced the discovery in foodstuffs of a substance or substances necessary for growth to which they gave the name **vitamines.** However, they had no conception of the nature of vitamines until McCollum published the results of his work showing that they contain two separate and distinct factors, each of which differs in several ways from the other and both of which are equally important, as is shown by the fact that the absence of either will cause failure of growth. He has termed one the fat soluble A and the other the water soluble B factor. Although nobody has yet determined their chemical properties, it is known that they are not destroyed by moderately high degrees of heat.

FIG. 32.—Pigs of the same age on a nutrition experiment. The animal on the left (55 pounds) received a ration of 95.5 parts of wheat meal and 2.5 parts of wheat gluten. The animal on the right (165 pounds) received a ration of wheat meal and skim-milk fed in approximately the proportions of 1:1. (Wisconsin Bulletin 291.)

Later the presence of both the essential fat and water soluble substances was demonstrated in alfalfa, clover, and cabbage leaves. It is probable that the leaves of all forage plants contain them. Be this as it may, there is no doubt that all seeds contain a much smaller amount of these substances than do the leaves. Butterfat contains an abundance of the fat soluble A, and skim-milk an abundance of the water soluble B. However, neither class of vitamines is constructed by the cow. The animal concentrates them from the feed and places them in the milk. In other words, the cow's feed must contain them, otherwise she would be unable to secrete normal milk.

One would expect to find the fat soluble A in all common fats.

However, examination shows that while it is abundant in butter-fat it is absent in lard, tallow, and other body fats, and also in cottonseed oil, a vegetable fat. Therefore, these fats cannot be substituted for butter-fat.

While these epoch making discoveries have not undermined the old idea that fats are a concentrated source of energy, which the animal stores in a time of liberal feeding to be drawn upon in a time of need as a source of heat or work energy, they do prove that all fats are not of equal value. Moreover, only fats from certain definite sources influence growth and reproduction.
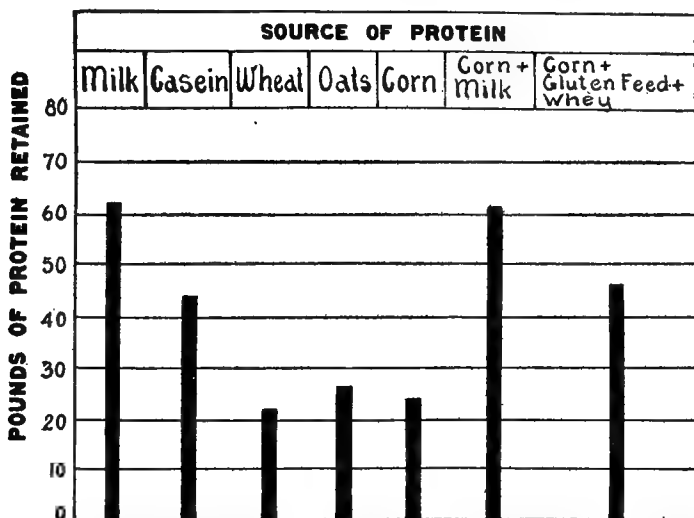
Fig. 33.—Showing the number of pounds of protein which a pig can retain for growth from each 100 pounds of protein consumed, when the proteins are derived from the different sources indicated. (Wisconsin Bulletin 291.)

Important as are these two dietary substances, it should be clearly understood that they are no more so than are the proteins, carbohydrates, water, and mineral constituents of the ration. For example, if any one of the eighteen or more amino-acids, which represent the cleavage products of protein digestion, is lacking, starvation will eventually follow. Figs. 32 and 33 illustrate variations in the nutritive value of proteins from different sources.

A series of experiments in which cows and pigs were used

brought out very clearly the rôle played by the inorganic salts in the ration. When cows were allowed a suitable salt mixture in their ration of corn, grain and wheat straw, they maintained a good state of nutrition and were able to produce vigorous calves. Later the same cows were fed on the same rations minus the salt mixture and while they were able to subsist themselves, they were unable to reproduce living offspring.

From the above facts it is clear that the following factors are necessary to make a ration adequate for nourishment: a sufficient amount of energy or fuel food; protein of poor, medium, or good quality; a suitable inorganic content; an adequate supply of the two as yet unidentified chemical substances belonging to the class of materials now called vitamines.

THE DUCTLESS GLANDS AND THEIR FUNCTIONS

The principal glands without ducts are the spleen, the thyroid, the thymus, the adrenals, and the pituitary and pineal bodies. They do not belong to the digestive system any more than to any other one system, but are described here for convenience. Although situated widely apart in the body and having no visible connection, they are dependent on each other. Little is known about the functions of these glands. In recent years it has been found that they play important rôles in the elaboration of the so-called *internal secretions*, which pass directly into the veins or lymphatics instead of being conveyed away by ducts. The active principles or hormones of their secretions act in a chemical manner to maintain what has been termed "the internal secretory balance." That they are necessary is shown by the fact that in most cases serious results follow their removal or disease. They regulate and correlate some of the most important physiologic functions of the body.

The **spleen** is the largest ductless gland. It is very vascular and is situated in the left portion of the abdominal cavity. In the horse it is sickle shaped, weighs a little more than 2 pounds, and averages 20 inches in length. It is bluish-red in color, and is soft but not friable in the natural state. The function of the spleen is not positively known, but it is supposed to have something to do with the formation and destruction of the red blood-corpuscles which are found in the organ in great numbers. Its

blood-vessels are capable of holding a considerable quantity of blood which increases after each meal reaching a maximum at about the fifth hour. Animals live with little inconvenience when it is removed.

The **thyroid gland** is composed of two lateral lobes connected by an isthmus. It is situated in the neck below the anterior part of the trachea and may be easily felt in the living horse. It is very vascular, firm in texture, and dark red-brown in color. Enlargement of the gland results in the disease termed "goiter." An important internal secretion containing iodine compounds, which has to do with the process of nutrition, is produced by the thyroid. Animals live but a short time after the entire gland, including the parathyroids, has been removed. If they are fed on fresh thyroid tissue from another animal they seem to suffer no inconvenience.

The **thymus gland** is found between the heart and the larynx. In late fetal life and in the very young animal it is seen as a long chain of gland-like tissue extending the entire length of the trachea. It atrophies rapidly after birth, and appears to have some regulating effect in the processes of growth and development of the fetus. As a food it is considered by many a delicacy, and is known as the "neck sweetbread." In animals castrated early it atrophies much slower than in others.

The **adrenals** are paired ductless glands situated in contact with each kidney (see Fig. 45). They are about 3 inches long and 1½ inches wide. A substance known as adrenalin has been extracted from the glands. It contains adrenin or epinephrin which is responsible for the powers of the extract. It exerts a powerful action on the small blood-vessels, contracting them to a marked degree, and causing an enormous rise in the blood pressure. The removal of the adrenals leads to rapid death preceded by great prostration and depletion, due to loss of the adrenal function of maintaining muscular and vascular tone.

The **pituitary** and **pineal bodies** lie at the base of the brain. Various theories have been advanced to explain their functions. The pituitary body is known to contain substances that exert an influence over blood pressure and metabolism. Experiments have shown that the administration of pituitary extract to lactating animals slightly increased the quantity of milk secreted and also its fat content. The increase is temporary, as the

extract becomes less and less effective as time goes on. Injections of pituitary extract are said to correct uterine inertia at parturition, to shorten the period of labor, and to prevent collapse by stimulating the heart. The pineal body is regarded as a dorsal eye of a remote ancestor. Disease of these bodies during early life prevents development of the genital organs and results in abnormalities in the shape of the bones. Their removal is fatal after a short interval.

THE RESPIRATORY SYSTEM

THE ORGANS OF RESPIRATION

The *respiratory apparatus* is concerned with the process of supplying air, a substance absolutely necessary to sustain the life of the animal. The importance of the air supply is shown by the fact that life will continue for weeks without food, days without water, but will cease to exist if the supply of air is cut off even for a few minutes.

The arrangement of the respiratory system resembles that of the digestive system in consisting of a tube which is lined with mucous membrane, but differs by communicating with the exterior at one end instead of both.

The organs of respiration comprise the nasal cavity, the pharynx, the larynx, the trachea, the bronchi, and the lungs. The lungs are the essential organs of respiration; all the other parts act as passages for air to and from them. Two accessory structures, the pleura and diaphragm, will also be briefly described in this chapter.

The **nasal cavity** is a cylindric passage divided by the cartilaginous *nasal septum* into symmetric halves. Its walls are made up of portions of all the facial bones except the mandible and hyoid. In the living animal it is lined by mucous membrane, which is continuous at the nostrils with the skin, at a slit-like opening near the roof with that lining the air sinuses, and posteriorly with the lining of the pharynx. The *nostrils* are supported and kept dilated by two comma-shaped alar cartilages attached to the nasal septum. In the horse a blind, pouch-like diverticulum of the skin, called the *false nostril*, lies above each nostril. The external opening of the nasolacrimal duct may be seen on the floor of the nasal cavity about 2 inches from the nostril when the latter is dilated. Two *turbinated bones* divide each half of the nasal cavity into three passages or meatuses—the superior, middle, and inferior. Of these, the inferior meatus is the largest,

and is the direct communication between the nostrils and the pharynx.

The **pharynx** has been described with the organs of the digestive system, as it is common to both the digestive and the respiratory tracts.

The **larynx** is a short tube-like apparatus situated between the pharynx and the anterior end of the trachea. It regulates the amount of air passing to and from the lungs and prevents the aspiration of foreign bodies. It is made up of five pieces of cartilage—the cricoid, the thyroid, and the epiglottis, which are single, and the arytenoids, which are paired. These cartilages articulate by true joints, and are moved by means of two systems of muscles—(1) the extrinsic group, which finds one attachment to the larynx and the other to some point outside the organ; (2) the intrinsic group, which is attached to the different cartilages. The interior of the larynx shows two *vocal cords* stretched from the lateral walls; the opening between these cords is called the *glottis*. When the vocal cords vibrate, sounds are produced. On each side of the larynx is a pocket-like depression of mucous membrane, known as the *ventricle*.

The **trachea** or windpipe is the tube that connects the larynx with the lungs. It is formed of fifty to fifty-five rings of cartilage, attached to each other by a fibro-elastic membrane. The rings are not complete circles, for their two ends overlap superiorly. Through these rings the organ is kept permanently open and is made flexible. The average caliber is about $2\frac{1}{2}$ inches. Its average length is about 31 inches. At the entrance to the lungs the trachea divides to form the bronchi.

The **bronchi** are two in number, the right being the larger. Together with the pulmonary vessels they form the "root of the lung." They are continued posteriorly by the smaller bronchial tubes, which ramify throughout the lungs.

The **lungs** are designated right and left. Together with the heart they practically fill the *thoracic cavity*. Three systems of tubes embedded in connective tissue are found in the lungs: (1) the ramifications of the bronchial tubes; (2) the pulmonary arteries; (3) the pulmonary veins. For description, each lung may be considered as having a base, an apex, and two surfaces. The base is situated against the diaphragm, which conforms to its shape. The apex lies apposite the first and second ribs. The

external surface is convex and adapted to the ribs and the inter-costal muscles. The internal surface is irregular and less extensive. In the living animal the lung is of a pinkish color, due to the blood in its tissues. It becomes pale gray in the bled subject, while the lung from an unbled subject is dark red. Lung tissue is soft, spongy, elastic and floats in water. Consequently the lungs are colloquially called "the lights."
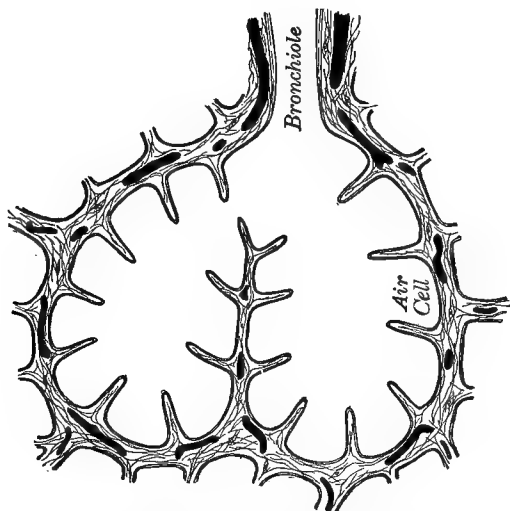
Fig. 34.—Diagram of a longitudinal section of two alveoli with their common bronchiole, and showing in black the larger blood-vessels in the walls. (From Hough and Sedgwick's The Human Mechanism, by permission of Ginn and Company, Publishers.)

A microscopic examination of the trachea shows it to be lined with a mucous membrane composed of ciliated epithelium interspersed with mucous cells. The bronchi and bronchial tubes have flakes of cartilage instead of rings of this tissue in their walls. This gives them a flexibility, and yet sufficient rigidity, so that they are extremely efficient as tubes for conducting the air. Each *bronchial tube* divides and subdivides until the extremely small tubes termed bronchioles are formed. *Bronchioles* end in minute blind compartments, about $\frac{1}{25}$ inch in diameter, known as alveoli. Each *air alveolus* has several air cells, as shown in Fig. 34. The *air cells* average only $\frac{1}{100}$ inch

in diameter. Their walls are very thin being composed of a single layer of epithelial cells, and supported and given elasticity by fibers of yellow elastic tissue. Capilliary blood-vessels course in the walls of the air cells (Fig. 34). The total area of the lung alveoli has been estimated at 100 times the area of the skin surface. The inner surface of the lungs of an average sized man, if spread out flat, would cover a space of 108 square feet.

The **pleura** is the serous membrane which lines the *thoracic cavity*. It is arranged to form two sacs, and is reflected at the roots of the lungs to invest these and other organs in the cavity. The median space between the two sacs is called the *mediastinum*. The disposition of the pleura is similar to that of the peritoneum. It is kept moist by a serous fluid, the liquor pleuræ; in health there is only enough to permit the lungs to glide on the walls of the cavity with the minimum amount of friction, but it accumulates rapidly in some forms of pleurisy.

The **diaphragm** forms the partition between the thoracic and abdominal cavities (see Fig. 36). It is a large muscle with a peripheral fleshy portion, two muscular pillars, and a tendinous center. The anterior surface is convex, covered by the pleura, and related to the bases of the lungs and pericardium. The posterior surface is concave, covered for the most part by the peritoneum, and in contact with the liver, stomach, flexures of the colon, and the kidneys. There are three foramina in the diaphragm—the dorsal one is for the passage of the aorta, the left one for the esophagus, while the right foramen gives passage to the posterior vena cava.

THE PHYSIOLOGY OF RESPIRATION

During life the lungs lie in an air-tight enclosure, the *pleural cavity*, in which there is a constant negative pressure. This keeps the lungs stretched from without and prevents them from collapsing, an essential to efficient preformance of work. In the average condition of expansion the normal elasticity of the lungs of a man is capable of supporting a column of mercury 30 mm. in height, so they are always tending to collapse. When the atmospheric air, with a pressure of 760 mm. of mercury, is admitted to the lungs at birth it immediately causes these distensible and elastic organs to inflate, because the normal atmospheric

pressure is greater, by about 730 mm., than that which tends to collapse them. This explains why the lungs are kept expanded and in contact with the chest wall under natural conditions. If the thoracic wall is perforated and the external air is allowed to rush into the pleural cavity, the lungs immediately collapse, driving a certain amount of air out through the trachea for now, in addition to the contractile force of the lungs, there is added the atmospheric pressure, against which is only the normal pressure from the air in the lungs. A collapsed lung is practically useless.
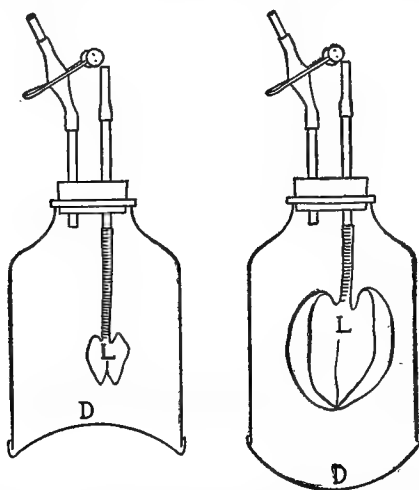
Fig. 35.—Apparatus to illustrate the mechanics of respiration: *L*, Lungs of experimental animal; *D*, rubber diaphragm. At the left the lungs are collapsed and the diaphragm relaxed, as occurs after expiration; at the right the diaphragm is contracted, which increases the negative pressure around the lungs and allows the air to rush into and expand them.

The **mechanism of breathing** may be best understood by studying the movements of lungs recently removed from a living rabbit, dog, or pig, and placed in an apparatus similar to that illustrated in Fig. 35. The glass bell-jar represents the thoracic walls. The jar is closed beneath by a sheet of rubber (*D*), to take the place of the diaphragm. Conditions that closely approximate the normal pleural cavity may be thus obtained. By partially exhausting the air in the bell-jar through the tube with the pinch-

cock attachment, a negative pressure may be made. If the sheet of rubber at the bottom of the apparatus is pulled downward, the size of the cavity will be increased and the pressure still further lowered, causing the air to rush in through the trachea and expand the lungs (*L*). When the pull is released, the pleural pressure rises, and the lungs tend to collapse and force the air out. The bell-jar used as a model for our illustration was larger than necessary, and may give a wrong impression, unless it is remembered that in life the lungs and other organs completely fill the thoracic cavity, so that no air space exists between them.

As the air that is inhaled passes through the nasal cavity, it comes in contact with the warm, moist mucous membrane which lines this passage and is spread out over the extensive surfaces of the turbinated bones. Here it is warmed and moistened so that no irritation occurs when it comes in contact with the sensitive lung tissue.

The ciliated cells in the trachea and bronchi continuously wave their cilia backward and forward to work the mucus, secreted by the large mucous cells previously mentioned, toward the mouth. This prevents the air sacs from clogging with phlegm and dust, as would occur in a little while if the foreign material were not removed.[1]

Respiration is a rhythmic process, that occurs from 8 to 16 times per minute in the horse, by which the exchange of gases between the tissues and the surrounding medium is made possible. The process is complex and involves a combination of the processes of absorption, secretion, and excretion. Although we think of the products concerned in respiration as being gases, they really must go into gaseous solution before they are available for use by the body. It will be remembered that food materials are rendered water soluble before they can be absorbed, as are all glandular products that are secreted and excreted, so the process of respiration does not differ materially from those carried on by other systems of organs. Absorption is very rapid from the respiratory mucous membrane for such readily diffusible substances as ether, chloroform, alcohol, and water.

[1] The action of cilia may be demonstrated by the "cork experiment" on the frog.

Colin poured seven quarts of water per hour into the trachea of a horse and upon autopsy at the end of three and a half hours did not find any water in the air sacs.

The process of respiration consists of two separate and distinct exchanges of gases: external respiration and internal respiration. The former both precedes and follows the latter.

External respiration, or breathing, is the exchange of gases between the external medium, air, and the blood. It consists of inspiration, a movement in which the lungs are filled with air, and expiration, by which the inspired air is expelled from the lungs and these organs are ventilated. Normally a short interval occurs between these movements.

Inspiration is brought about by a contraction of the diaphragm, which causes this partition to flatten, particularly at the sides, so that the length of the thorax is increased (Fig. 36). The ribs are rotated outward and forward by the external intercostal muscles attached to them. As a result of these changes both the girth and transverse diameter of the chest are increased, and the thorax is greatly expanded, so as to permit the maximum intake of air. Inspiration requires exertion.

Expiration is made possible by

Fig. 36.—Horizontal section of chest of horse to show the movements of diaphragm: *a*, Right lung; *b*, left lung; 1, position of the diaphragm during deep expiration; *c*, liver; *d*, stomach during deep expiration; *e*, spleen during deep expiration; 2, position of the diaphragm during deep inspiration; *c'*, liver; *d'*, stomach; *e'*, spleen; *f*, posterior vena cava as it passes through its foramen in the diaphragm. (Sussdorf.)

the relaxation of the muscles employed in inspiration. Normally it is mainly a passive act; no muscular effort being required. The diaphragm springs forward rapidly, due to pressure from the abdominal viscera. This causes the lungs to be compressed, and forces most of the air out of them. The balance of the air normally exhaled depends for its expulsion on the contraction

of the internal intercostal muscles, which help draw the ribs backward and downward.   When breathing is forced or labored, these and the abdominal muscles also come into play to aid in reducing the size of the thorax.

The air which is exhaled in normal, quiet respiration is known as tidal air; the supplemental air is that which can be voluntarily breathed out after a quiet expiration; the residual air is that which the animal is unable to force out of the lungs. To show that residual air is present in considerable amount, the lungs of a recently killed animal should be placed in water, in which they will be found to float.   Fetal lungs sink in water, for the air-cells have never been filled with air.

Internal respiration, true respiration, or oxidation, consists of the passage of oxygen from the blood to the tissues, and the passage of carbon dioxid and other impurities from the tissues to the blood.   The process is one of the fundamental properties of protoplasm and was referred to in Chapter I under *Katabolism*. The blood is constantly supplying oxygen and removing carbon dioxid.   The balance between these gases in the cells is maintained by the cell protoplasm, which has a marked attraction for oxygen.

Two theories have been advanced to explain the exchange that takes place between the gases in the alveolar air and the gases in the blood of the pulmonary capillaries, and the corresponding interchange between the blood and the tissue cells.

One theory is that a simple mechanical diffusion of the gases occurs.   It is claimed that diffusion results from the difference in tension, the process being one of passing gases from a place of lower tension to that of a higher.   By studying the accompanying tables, which show the average per cent. of the different gases in the inspired and expired air, and in the arterial and venous blood respectively, a conception may be had of the extent and nature of the gaseous exchanges.

	O	CO_2 and CH_4	N
Inspired air	21.0	0.0	79
Expired air	16.5	4.5	79
Difference	4.5	4.5	0

The above table shows that the respired air loses oxygen and takes up carbon dioxid and methane.   Of the latter two gases

the first is largely derived from oxidation of the various organic compounds of the body and is the guide to the extent of tissue activity, while the second comes, in most part, from the destruction of cellulose in the intestines.

	O	CO_2 and CH_4	N
100 cc. arterial blood	20 cc.	38 cc.	1.5 cc.
100 cc. venous blood	10 cc.	48 cc.	1.5 cc.
Difference	10 cc.	10 cc.	0.0 cc.

This table represents the difference between the gases in arterial blood and those in venous blood. It shows that there is always a considerable amount of deleterious gases in arterial blood, and a corresponding amount of life-giving oxygen in venous blood. Furthermore, it shows that the tissues do not remove all the oxygen, nor do the lungs remove all the carbon dioxid and methane from the blood circulating through them.

The other theory is based on the fact that the lung and capillary endothelial cells, which form very thin walls through which the gases must pass, have the power actually to absorb and to secrete gases. This property has been termed "vital action" in lieu of more specific knowledge. In these premises it is not necessary to have physical forces operating. Many investigators have attempted to duplicate the experiments but have not entirely succeeded. The theory is therefore not generally accepted.

Throughout the entire existence of the animal the waste products which are formed in the tissues as a result of oxidation are removed by the process of internal respiration. The source of these products and the method by which the body disposes of them will now be considered.

The oxidation of proteins (amino-acids) in the tissues results in the formation of ammonia and other waste products which are taken to the liver and converted into urea. This substance is passed to the kidneys for excretion. Some water and carbon dioxid are also produced; the former escapes through the lungs, the kidneys, and the skin, while the latter is largely disposed of by the lungs in the exhaled air.

The oxidation of fats in the tissues takes place according to the following equation:

$$C_{51}H_{98}O_6 + O = 51CO_2 + 49H_2O$$
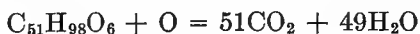
In other words, when fats are broken down their end-products are carbon dioxid and water.   The same thing is true of the carbohydrates to which the equation below applies:

$$C_6H_{12}O_6 + O = 6CO_2 + 6H_2O$$
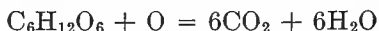
Normally a perfect balance is maintained in the blood between the production of carbon dioxid and the consumption of oxygen by breathing either faster or slower.   The rapidity of breathing is regulated by a collection of nerve-cells in the medulla oblongata known as the *respiratory center*.   Special nerve fibers run from this center, by way of the vagus nerve trunks, to the lungs and muscles concerned with respiration.   Like other important nerve centers, it is automatic, that is, when its vagus nerve connections are severed it continues to discharge impulses.   In this event, however, the respiratory movements are not sufficient properly to aerate the blood and the animal sooner or later succumbs to carbon dioxid poisoning.

Carbon dioxid, when raised above a certain level in the blood by exercise or any other cause, stimulates the respiratory center to discharge rapidly.   There results from this, by reflex action, a series of contractions in the muscles of respiration, an increase in the number of respirations per minute, and rapid ventilation of the lungs.   The action is due to the direct influence of the carbon dioxid on the cells of the center, rather than to the accumulation of this gas in the blood, for it is readily eliminated from the blood as the latter flows through the lungs.   These cells may accordingly be looked upon as agents to protect all other body cells from carbon dioxid poisoning.   When this gas is in excess it produces, besides a marked increase in the number of respiratory movements, great depression, and finally tranquil death from paralysis.

On the other hand, when a decrease occurs in the amount of oxygen in the blood, the respiratory center is but slightly stimulated to action.   The effects are best observed at high altitudes where the atmosphere is rarefied.   This is because the hemoglobin of the blood has the power of taking oxygen from air that contains less than that normally breathed, so the effects of diminished oxygen in the air are not at once noticeable.   If oxygen is withheld, animals exhibit great excitement, cyanosis, dizziness, albuminuria, and convulsive death, but little or no increase in

the number of respiratory movements. This shows that a deficiency of oxygen does not cause stimulation of the respiratory center to such an extent as results from an increase in carbon dioxid.

The amount of oxygen in the blood leaving the lungs cannot be materially increased even by causing the animal to breathe deeply or by offering it pure oxygen gas to breathe, as the blood normally is near the point of saturation. This means that increased ventilation of the lungs without an accompanying increase in the rate and force of the heart beat will not supply more oxygen to the tissues.

Asphyxia is the condition of suffocation that results from an increase of carbon dioxid or a decrease of oxygen in the blood.

Dyspnea is the condition of distressed or labored breathing caused by lack of air. The affected animal is said to be "air hungry." It is seen in wind broken horses and those affected with heaves after violent exercise.

The amount of oxygen absorbed and other gases excreted varies with the size of the animal, the activity of the tissues of the body, the rate and depth of respirations, and the body temperature. In a state of rest a horse of 1100 pounds weight has been found to absorb 5260 liters of oxygen, and give out 5060 liters of carbon dioxid in twenty-four hours. During exercise these amounts are greatly increased due to more rapid combustion of the carbon-containing materials in the tissues. Exposure to cold causes increased oxidation and a corresponding increase in the respiratory exchange. In a fasting animal respiratory activity is slow; on a non-nitrogenous ration it is somewhat more rapid, still more rapid on a mixed ration, and most rapid on a nitrogenous ration.

The amount of air breathed by a horse was found by King to be 142 cubic feet per hour and about 3400 cubic feet per day. This demand quickly uses up the air in the immediate vicinity of the nose for an equal amount of air that has been breathed is discharged. It is obvious that a constant stream of fresh air is needed to remove the vitiated air and to supply oxygen. This calls for some means of keeping the air in motion. The electric fan and window ventilators are used in our homes for this purpose. In the stable air shafts are employed. For most effective

results the ventilating flues should be installed as illustrated in Figs. 37 and 38.

It has been shown that farm animals, under ordinary stable conditions, cannot decrease the oxygen or increase the carbon dioxid content of the air to an extent dangerous to life. Even when the oxygen content of the air was reduced from about 21 per cent. to as low as 5 per cent., and the carbon dioxid raised to 2.67 per cent., no appreciable detrimental effect was noticeable.
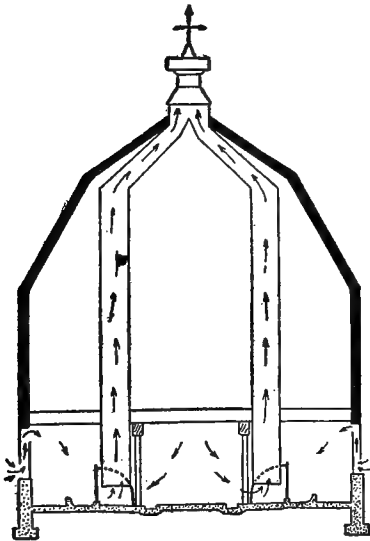
FIG. 37.—Ventilating flues when cows face out.
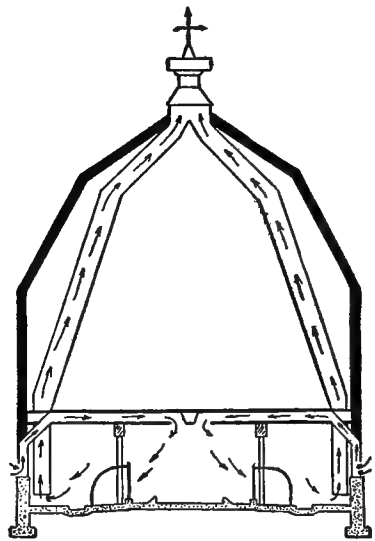
FIG. 38.—Ventilating flues when cows face in.

Similar results have been obtained when human beings were confined in an unventilated room. The reason why persons and animals get on so well in houses and stables with apparently no ventilation is that air is constantly entering and leaving through the cracks, crevices, and pores in the walls.

The qualities that determine whether air is good or bad are: temperature, humidity, odor, and motion. The oxygen and carbonic acid gas content are of minor consideration; therefore,

neither of these gases can be used to measure the suitability of air for breathing purposes.   Bad air is too hot, too humid, has a bad odor, and is still; good air is moderately cool, moderately dry, has no odor, and is in motion.   The best temperature of air for breathing is around 50°F. and the most satisfactory humidity 50 to 60 per cent.

THE CIRCULATORY SYSTEM

THE ORGANS OF CIRCULATION

THE *organs concerned with the circulation of blood and lymph* are the heart, the arteries, the veins, the capillaries, and the lymphatics.
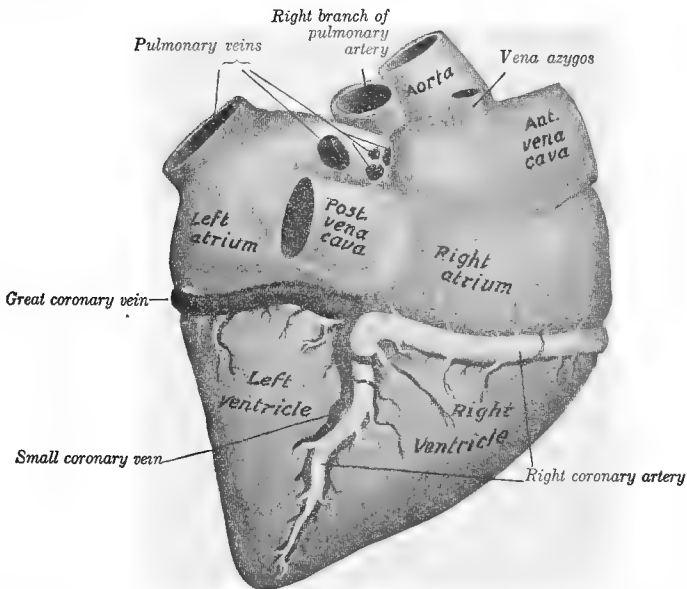
FIG. 39.—Right view of heart. The pericardium, epicardium, and subepicardial fat have been removed. Cardiac vessels are injected. (Sisson, Anatomy of Domestic Animals.)

The **heart** is the central organ of this system (Figs. 39, 40). It is composed of muscle tissue and is situated in the thorax, between the lungs and opposite the third to sixth ribs. It is attached at the base to the large blood-vessels. It rests on nothing, the apex being clear of the sternum. The average weight

126

of the heart of the horse is $7\frac{1}{2}$ pounds; of the ox $5\frac{1}{2}$ pounds. This difference is in keeping with the character of the work performed by each animal.

The *pericardium*, a fibrous sac lined with a serous membrane, surrounds the heart. In it is found a characteristic secretion, the *pericardial fluid.*
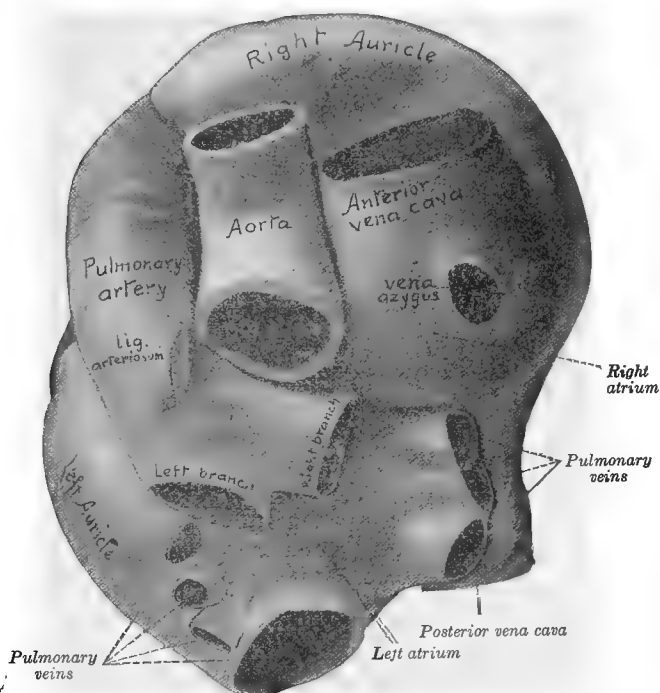
FIG. 40.—Base of heart of horse, with large vessels. Photograph of specimen hardened *in situ.* (Sisson, Anatomy of Domestic Animals.)

When the heart is opened by incisions for inspection it is seen to present four cavities—the right and left auricles and the and the left ventricles (Fig. 41). The two cavities of one side are partitioned off from those of the other by a septum of fibromuscular composition that keeps the pure and impure blood separated. The right anterior part of the base of the heart is formed by the **right auricle.** It has orifices for the anterior

and posterior vena cava, and in the ventral part the right auriculoventricular orifice, which leads into the right ventricle. This orifice is guarded by the tricuspid valve. By means of this and the other valves the blood is kept flowing in one direction. The **right ventricle** occupies the right anterior part of the ventricular mass, but does not reach the apex. It communicates
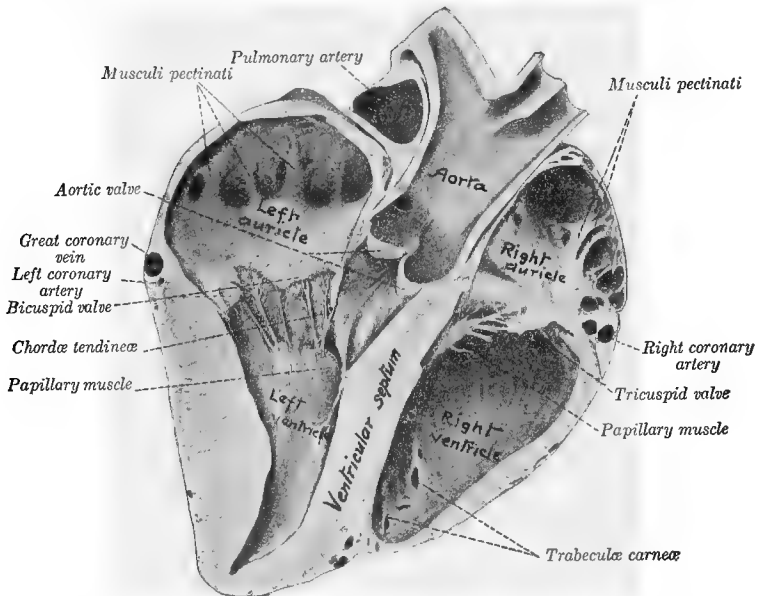
FIG. 41.—Section of heart of horse. The section is cut nearly at right angles to the ventricular septum, and is viewed from the right. (Sisson, Anatomy of Domestic Animals.)

with the pulmonary artery through the pulmonary orifice, which is guarded by the semilunar valve composed of three cusps. The **left auricle** forms the posterior part of the base of the heart. Seven or eight pulmonary veins open into this cavity. Below, it communicates by the left auriculoventricular orifice, which is guarded by the bicuspid valve, with the left ventricle. The **left ventricle** discharges blood through the aortic orifice. This opening is guarded by the aortic semilunar valve similar to but stronger than the corresponding valve on the right side. All

cavities of the heart are lined with a glistening membrane, the endocardium, which is continuous with the lining of the arteries and veins.

Arteries are the tubes that carry the blood from the heart to the tissues. Their walls are thick, strong, and contain much yellow elastic tissue which renders them extensible. When empty they do not collapse. Most arteries occupy protected situations and are straight in their course. When a vessel has to accommodate itself to the movements or contour of a part it makes a bend. Arteries communicate freely with one another, thus promoting equality of distribution and pressure and making
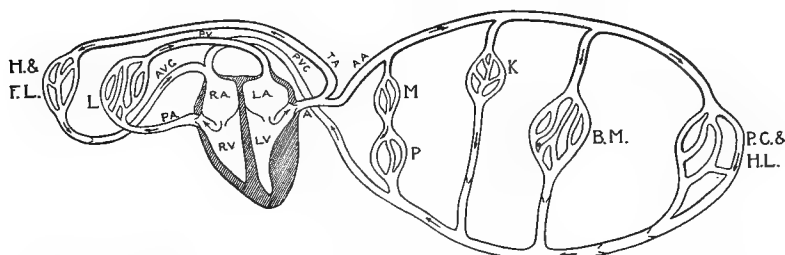
Fig. 42.—Diagram of the circulation: *L*, Pulmonary circulation; *H*. and *F.L.*, circulation through the head and fore limb; *M*, mesenteric circulation; *P*, portal circulation; *K*, renal circulation; *B.M.*, circulation through the body muscles; *P.C.* and *H.L.*, pelvic cavity and hind limb; A.v.c., anterior vena cava; P.v.c.. posterior vena cava; P.V., pulmonary vein; A., common aorta; T.A., thoracic aorta ; A.A., abdominal aorta; R.A., right auricle; L.A., left auricle; R.V., right ventricle; L.V., left ventricle. The shaded vessels carry arterial blood, the others venous blood.

good circulation possible even after a large vessel becomes obliterated. A single larger vessel, the pulmonary artery, takes origin from the right ventricle, and another, the aorta, from the left ventricle.

The **pulmonary artery** carries dark or venous blood from the right ventricle to the lungs, where it divides into numerous small vessels that ramify in the lung tissue.

The **aorta** gives passage to the red blood from the left ventricle (Fig. 42) that supplies all the organs of the body except the lungs. It is a short vessel that soon divides into thoracic and abdominal parts. Its walls are much thicker than those of the pulmonary artery, as the blood is under greater pressure.

9

The **common brachiocephalic artery** is the name of the thoracic division of the aorta. In the horse it is directed forward and upward to supply the fore limbs, neck, and head.

The **posterior aorta** or abdominal division of the aorta, arches backward and pierces the diaphragm. It supplies branches to the walls and viscera of the abdominal cavity, the body muscles, and the pelvic organs and limbs.

Capillaries are the minute, microscopic continuations of the arteries that connect the latter with the veins. In many cases they are not much larger in diameter than a red blood-corpuscle. Their walls often consist of but one layer of cells through which the interchange of gases between the blood and the tissues takes place. The sectional area of the capillaries is about seven hundred times that of the aorta.

Veins are satellites of the arteries and conduct the blood back to the heart from the tissues. They have thinner walls than the arteries, are less elastic, and collapse when not filled with blood. In many veins the internal coat is folded up to form valves, the free edges of which are directed toward the heart to prevent the blood from flowing backward. The venous system has a capacity two or three times greater than the arterial. Beginning at the capillaries the veins unite to form larger and larger tubes as they approach the heart until the pulmonary veins are formed on the left and the venæ cavæ on the right.

The **pulmonary veins** carry the blood which has passed through the lungs and has become oxygenated to the left auricle.

The **anterior vena cava** carries the blood returned from the head, neck, and thoracic limbs to the right auricle.

The **posterior vena cava** is the largest vein in the body and conveys nearly all the blood from the liver, spleen, intestines, other abdominal and pelvic organs, and the pelvic limbs to the right auricle.

Lymphatics consist of a network of connecting lymph channels and groups of lymph-glands.

The **lymph channels** are not continuous vessels, like the arteries, so should not be thought of as comprising a complete circulatory system for the lymph as do the arteries and veins for the blood. The movement of the fluid which they carry is wholly centripetal and therefore comparable in direction with the flow of blood in the veins. The lymph is formed in the tissues and

drains away quite gradually, eventually losing its identity. The larger lymph channels are provided with simple valves to prevent a backward flow of the lymph. These channels conduct the lymph from nearly all parts of the body to the great reservoir located in sublumbar region known as the *receptaculum chyli*. The *thoracic duct* conducts the lymph from this reservoir to the anterior vena cava at the junction of the jugular veins near the base of the heart (see Fig. 31). This duct in the horse is about half an inch in diameter but is not of uniform caliber throughout its length.

The **lymph-glands** lie along the course of the lymph channels. Each organ of the body is provided with one or more lymph-glands. They act as filters for the lymph, and are very important structures in maintaining the health. The bronchial lymph-glands are located at the bifurcation of the bronchi, and are usually discolored from the large amounts of very minute particles of carbon and dust which they have caught. In tuberculosis and some other diseases, the lymph-glands early become infected with the microörganisms which they have enmeshed, and become greatly enlarged.

The **circulation** is the term applied to the entire circuit which the blood must traverse in its course from a given point and return. In reality the blood makes a double circuit; that from the right ventricle to the left auricle being known as the *pulmonary* or *lesser circulation*, and that from the left ventricle to the right auricle the *systemic* or *greater circulation*. The general arrangement of the organs and course of the circulation is shown in Fig. 42. All the blood in the body circulates through a man's lungs once every twenty-three seconds; in the horse it takes a little longer. More than three-quarters of all the blood is probably in the systemic circulation at any given moment.

THE PHYSIOLOGY OF CIRCULATION

The method by which the blood circulates was not discovered until 1621, when Harvey showed how the blood flows and the heart functions. Before that time it was thought that the blood ebbed and flowed like the tide. Through the constant contraction and relaxation of the heart muscle the circulation of the blood is maintained.

The **heart movements** may be best studied by removing the

heart of a turtle or frog and placing it in a beaker containing a balanced salt solution. The series of movements through which the heart goes is termed a **cardiac cycle.** In the horse at rest it takes about two seconds to complete this cycle. At the beginning there is a contraction of the muscular walls of the heart by which the blood is forced out of the ventricles into the arteries. This movement is called systole. It causes the heart to shorten and become globular. Immediately the heart muscles relax, which causes the auricles to dilate to their full extent and fill with blood from the several large veins emptying into them. This movement is termed diastole. When these movements are completed the heart pauses or comes to a rest, and the cardiac cycle is finished. Although very short, the resting period is sufficient to permit the heart to recuperate from its labor, so as to be prepared for another similar series of movements. The right and left sides of the heart move synchronously.

An intricate group of nerves control the heart movements. They are derived from branches of the two vagi, each of which has a plexus near the base of the heart to influence the rate and force of the heart's movements. One set of these nerves conveys impulses which stimulate the heart to increased activity, and are known as the **accelerator nerves.** Another set of nerve fibers produces exactly the opposite effect and causes the heart to beat slower and with less force, acting as a governor does on an engine. These are termed **inhibitor nerves** from their action. When the connections between the nervous system and heart are severed the result is a quickening of the beat. This indicates that the prevailing influence of the centers is inhibitory. In the walls of the blood-vessels are found **vasoconstrictor nerves** and **vasodilator nerves,** which regulate the size of the vessels by acting upon the muscle-fibers in their walls. When a profuse supply of blood is required by the stomach, immediately after a meal, for example, to furnish the gastric glands which are extremely active at that time with substances to replace those secreted, the vasodilator nerves come into play. The result is a physiologic congestion of blood in the organ. The *vasomotor nerve center* is located in the medulla.

The **heart beat** is the term commonly used for the complicated series of changes just described. In healthy adult horses the heart beats from 28 to 40 times in a minute; in foals the beat is more frequent, varying from 45 to 100 times in a minute.

Blood pressure is higher in the arteries than the veins. The difference is shown when an artery and a vein are cut; the blood spurts from the artery in a pulsating jet, while the flow from the vein is gentle, more constant, and easily checked.

Arterial blood pressure has been determined by connecting the femoral artery of a prostrate horse with a vertical glass tube; the blood was found to rise to a height of 10 feet in the tube. Smith states that at each stroke about 2.25 pounds of blood are pumped into the aorta of the horse. From these figures the work of the left ventricle with each systolic movement is found to be equivalent to raising 22.5 pounds one foot. On account of the greater resistance in the peripheral arteries and capillaries than in their pulmonary counterparts, the work of the left heart has been estimated to be four times that of the right. This should give some idea of the energy expended by the body in simply sustaining the circulation in a state of repose and the importance of keeping it in working order.

Venous blood pressure may be shown by the same method as that described for measuring the arterial pressure. A vein connected up with a vertical tube will force a column of blood but a few inches high into the tube. Venous pressure is largely dependent upon external pressure which is exerted in the following ways:

(1) Respiratory movements, as was explained in the chapter on Respiration, result in expansion and contraction of the thorax. During inspiration there is a negative pressure in the thorax and the blood is sucked into the large intrathoracic veins in much the same way that the air is into the lungs. The greater thickness of the walls of the arteries prevents in large measure this effect on them. During expiration the reverse action would take place, and the blood would be forced back into the tributary veins if they were not provided with valves. As there are no valves in the pulmonary veins and those opening into the right auricle, the blood in them flows into the upper chambers of the heart.

(2) Muscular contractions result in a shortening and thickening of muscles. This brings about compression of the veins which lie in and between the muscles and forces the blood from the smaller into the larger veins, the valves, as already stated, preventing any backward flow. The more rapidly a muscle contracts, the greater is the amount of blood circulating through it.

The **velocity of blood-flow** should not be confused with pressure. In order that velocity be reduced, the path must be widened, while reduction in pressure means resistance overcome. Velocity may increase by the contraction of the channels, but pressure never is increased if the flow is in horizontal vessels; it can only decrease. The rate of blood flow is highest in the aorta, lower in the large venæ cavæ, and very slow in the capillaries. It may take a full second for a given corpuscle to pass through a capillary $\frac{1}{25}$ inch in length. In the aorta the velocity is 300 times faster.

The explanation of the velocity fall from a maximum in the aorta to a minimum in the capillaries followed by an increase in the veins is not hard to understand (Fig. 43). It is merely that in any stream the velocity is greatest where the cross-section of the channel is least and lowest where it is greatest. This may not be apparent unless it is recalled that the sectional area of the capillaries is several hundred times that of the aorta. It has been found that in the horse it takes about half a minute for a substance in solution to pass from the jugular vein down through the right side of the heart, the lungs, the left side of the heart, up through the arteries of the neck and head, and so back to the jugular vein where the substance was introduced. The greater portion of this half minute is taken up during the passage through the capillaries.

Fig. 43.—If a vessel (a) divides into two branches, (b) and (c), these will be individually of less cross-section than the main trunk but unitedly they will exceed it. Linear velocity will be lower in the branches than in the parent stock. (Stiles, Human Physiology.)

The **movement of lymph** is due to the same agencies responsible for the flow of blood in the veins. There are valves in the lymph channels which permit the fluid to advance toward the heart but forbid a return.

Good circulation is possible only when the animal has opportunity for exercise. When exercise is provided, breathing is deeper and the skeletal muscles are rapidly contracted and relaxed. This causes the blood to be pumped out of the veins and the lymph to flow freely in the lymph channels.

THE PROPERTIES OF THE BLOOD AND LYMPH

The **blood** is a red fluid, alkaline in reaction, with a peculiar odor thought to be due to a volatile fatty acid. The specific gravity of horse blood is 1060. When drawn from an artery the blood has a bright scarlet color. Venous blood is dark red in color, but on standing in the air readily becomes scarlet, due to the absorption of oxygen. The total amount of blood is equal to about one-fourteenth of the body weight.

Blood contains about 750 parts of water to 250 parts of solids. The proportion of water and solids is but little increased by drinking and only slightly decreased by thirst. The balance, as has been explained, is maintained by the kidneys. The principle solids consist of sodium chlorid, calcium, magnesium, and potassium salts, hemoglobin, various proteins, lecithin, sugar, urea, phosphoric acid, uric acid, creatin, creatinin, and traces of cholesterin and fat.

Blood-corpuscles are the formed elements of blood. They are of two kinds, viz., white and red, and are present in the proportion of about 1 to 500 respectively. The *white corpuscles*, or *leukocytes*, are colorless nucleated cells. Several kinds are recognized and the proportion existing between them is a valuable guide in diagnosing diseases. Some originate in the red marrow of bones, others in the lymph glands. By virtue of their ameboid movement they have the ability to pass through intact vessel walls without causing harm. They are active agents in protecting the body against disease-producing microörganisms through their

Flat view

Side view

Rouleau

Rouleau

Fig. 44.—Red blood-corpuscles. Several are shown in different positions. The biconcave shape when viewed from the edge is clearly evident. (Hill's Histology.)

phenomena of engulfing and ingesting foreign particles with which they come in contact. On account of possessing these powers, they are sometimes known as phagocytes or eating cells. The *red corpuscles*, or *erythrocytes*, are biconcave disks, without nuclei, measuring $\frac{1}{4500}$ inch in diameter in the horse

(Fig. 44).   They are surprisingly uniform in size, but are smaller in mammals than in reptiles and amphibians.   They originate in the red marrow of bones and are destroyed in the liver and spleen.   In very thin layers they appear yellow in color, but under ordinary conditions are red from the hemoglobin, a pigment, which they contain.   They give the blood its characteristic red color.   There are from 5 to 6 millions in each cubic millimeter of blood.   Calculations have placed the total surface of the red corpuscles as high as one acre for one horse.

Hemoglobin is a protein substance, making up about 90 per cent. of the solid part of the erythrocytes.   It has the remarkable property of combining with oxygen in the lungs and of releasing this gas when it comes into a situation where there is a relative lack of the element, as is found in the tissues.   The union in the lungs of the hemoglobin and oxygen forms a temporary chemical compound called *oxyhemoglobin* which is bright red in color.   As the blood flows through active tissues whose cells crave oxygen the red corpuscles yield more or less of their oxygen. Insofar as they do this, their oxyhemoglobin is changed to what is known as *reduced hemoglobin* which is blue-black in color and the more of it there is present the darker the blood.

Blood-plates are bodies of smaller size than the red corpuscles.   They are found in the blood.   From the fact that they disappear as soon as blood is drawn from the vessels, they are thought to have something to do with the clotting of blood.

Blood-plasma is the fluid part of living blood in which the blood corpuscles live and are transported.   It constitutes about one-half the volume of the blood.   Four-fifths of its total solids are albuminous in character, consisting largely of fibrinogen, nucleoprotein, serum-albumen, and serum-globulin.   The significance of these substances is obscure; at present they are thought to be rather permanent, little subject to depletion, and not consumed as food by the tissues.

Blood-serum is the clear, amber-yellow fluid that is expressed from the clot when it shrinks.   It differs from the plasma in containing no fibrinogen.

Blood clots or coagulates when it is taken from the blood-vessels and after death.   The property of clotting completely checks hemorrhage from small vessels.   A clot resembles jelly and contains the same elements that are found in living blood

with the exception that the soluble fibrinogen has been changed by the action of the enzyme thrombin to the insoluble fibrin. The fibrin forms a fine meshwork, which holds the corpuscles firmly together. There is evidence that the blood-plates disintegrate almost immediately after coming in contact with a foreign surface and release a substance which renders the enzyme thrombin effective. When fresh blood is drawn into a beaker and defibrinated, by whipping with a stiff wire or shaking with glass beads, the fibrin separates out as an elastic, stringy mass. The corpuscles in defibrinated blood being heavier than the serum, gravitate to the bottom of the fluid. As the red blood-corpuscles are heavier than the white blood-corpuscles, the latter form a thin layer on the surface of the former.

The **functions of the blood** may be summarized as follows: Blood carries oxygen from the lungs and food materials from the alimentary canal to the tissues; it receives carbon dioxid and other waste products of activity from the tissues and transports them to the organs of excretion through which they are eliminated; it distributes heat and assists in equalizing the body temperature by carrying heat to the surfaces of the body where it can be dissipated; it carries hormones from organ to organ; it neutralizes toxins and destroys bacterial invaders. It may be considered as an extension to the external media (air and water) for the transportation of gases between the lungs and tissues, and water-soluble substances between the digestive canal and the tissues.

Lymph is not secreted by the lymph-glands in the sense that saliva is by the salivary glands, but comes from the fluid osmosed through the blood-vessel and cell walls. A sample taken from a small lymph-channel, or a "water blister," is a straw-colored fluid which has less tendency to coagulate than blood. That coming from the lacteals or receptaculum chyli is thicker and milky in appearance, due to the presence of the fats absorbed from the alimentary canal, and is termed *chyle*. Lymph contains numerous *lymph corpuscles*, or *lymphocytes*.

The **functions of the lymph** are to carry nutritive substances from the blood to the tissues and convey away waste materials, and to act as a lubricant. The latter function is seen when an examination is made of the synovia of the joints and the pericardial, pleural, and peritoneal fluids, all of which contain consid-

erable lymph to reduce friction. It is helpful to think of the lymph as a central station or middleman between the blood and the tissues.

The presence of an excessive amount of lymph in a tissue results in a cool swelling which pits on pressure, as there is no circulatory movement in the lymph-spaces to force it along.

CHAPTER VII

THE UROGENITAL SYSTEM

THE URINARY ORGANS

The structures concerned with the processes of *urine secretion and expulsion,* and those that have to do with *reproduction* are studied together, because some of them serve both as passages for the urine and the products of the genital organs.

Ureters

Left

Aorta

Renal vein

Kidney

L. Adrenal.

Vena cava

Right

R. Adrenal

Kidney

Anterior mesenteric artery (stump)

Renal arteries
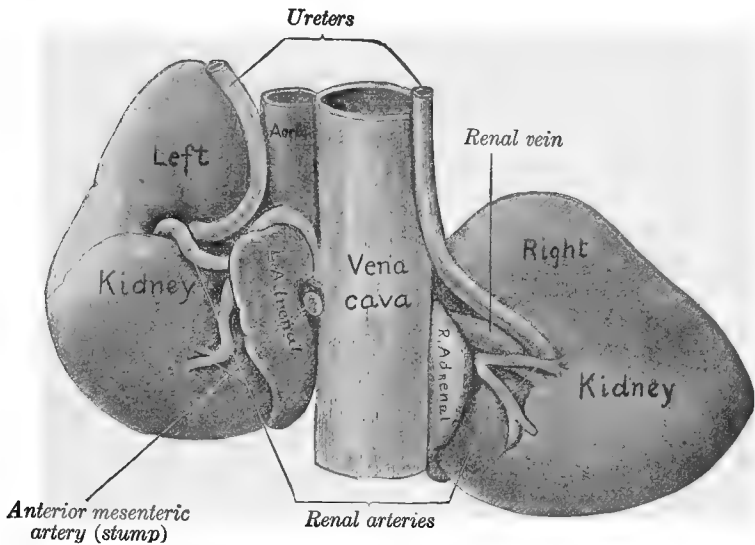
FIG. 45.—Kidneys and adrenal glands of horse, ventral view. Photographs of organs hardened *in situ.* (Sisson, Anatomy of Domestic Animals.)

The urinary organs consist of the kidneys, the ureters, the bladder, and the urethra.

The **kidneys** are paired glands having a smooth surface in the horse, sheep, and hog; but lobulated in the ox. They are found highly developed in the most primitive animals in which even such important structures as the lungs and brain are undeveloped. This shows that they are highly essential organs. The right

139

kidney of the horse is heart shaped, weighs about 23 ounces, and is placed under the upper ends of the last two ribs and the transverse process of the first lumbar vertebra (Fig. 45). It is in contact with the liver in front and the pancreas below. The left kidney is bean shaped, weighs about 22 ounces, and lies about 2 inches further back than its fellow.

Each kidney has on the inner border a hilus or opening for the ureter and renal artery, vein, and nerves. A tough, fibrous capsule, which can be easily stripped off, covers each kidney. On section, two distinct zones of kidney substance are seen (Fig. 46). The outer or cortical substance is reddish-brown in color, and contains many minute, dark, pinhead points, which are blood-vessel tufts. The inner or medullary substance is lighter in color and appears striated, due to the hundreds of uriniferous tubules. The *pelvis* is the central cavity or basin where the urine is received from the collecting tubules. The renal artery is remarkable for its great size.
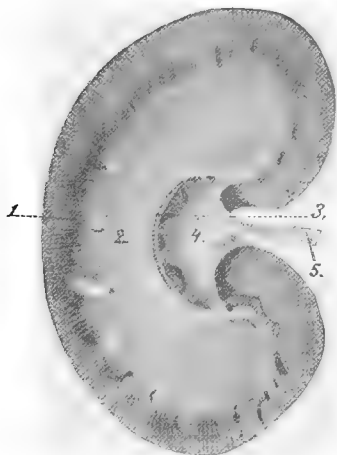
FIG. 46.—Kidney of sheep; horizontal section. 1, cortical substance; 2, medullary substance; 3, renal crest; 4, renal pelvis; 5, ureter. (From Leisering's Atlas, reduced.)

The kidney is composed of numerous tubules closely associated with blood-vessels (Fig. 47). Each *uriniferous tubule* commences at a closed, expanded end which surrounds the *glomerulus*, or tuft of capillary blood-vessels, the whole mechanism being known as the *malpighian corpuscle*. The tubule projects into the kidney substance in a convoluted manner, forms two loops, and finally opens into a collecting tubule which conveys the urine to the pelvis of the kidney.

The **ureters** are thick-walled ducts of small caliber, which connect the kidney with the bladder. Their course is along the sublumbar muscles into the pelvic cavity. They have muscle-fibers in their walls. The backward passage of the urine into

the ureters is prevented by the oblique manner in which they pierce the wall of the bladder.
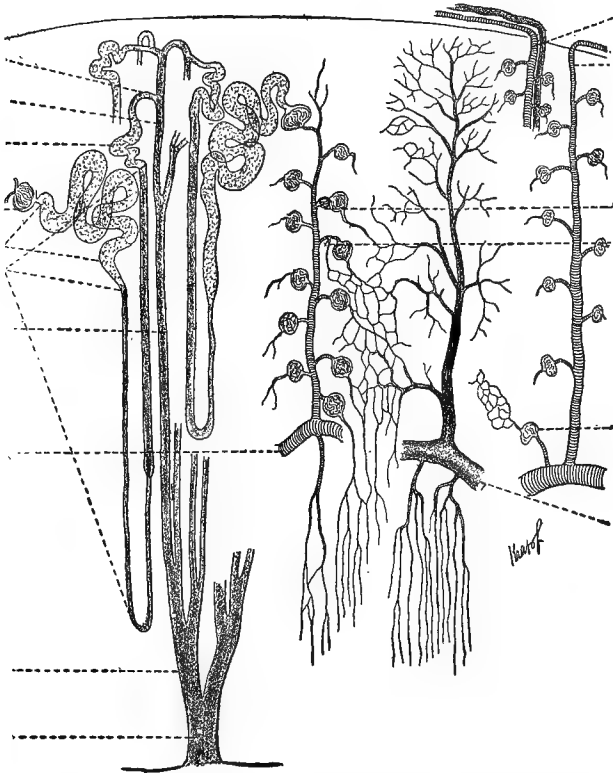
Fig. 47.—Diagrammatic scheme of uriniferous tubules and blood-vessels of kidney: *a*, Arched collecting tubule; *b*, straight collecting tubule; *c*, distal convoluted tubule; *d;* renal (malpighian) corpuscle; *e*, proximal convoluted tubule; *f*, loop of Henle; *g*, collecting tubule; *h*, arteria arciformis; *i*, large collecting tubule; *j*, papillary duct; *k*, artery of capsule; *l*, interlobular artery; *m*, capillary network, vas afferens; *n*, arteriola recta spuria; *o*, glomerulus; *p*, vena arciformis. (Böhm, Davidoff, and Huber.)

The **urinary bladder** is located on the floor of the pelvis. When full it is egg-shaped, and may extend over the brim of the pubis into the abdominal cavity. Near its posterior or constricted part are found the openings of the ureters. The wall

is composed of an inner mucous coat, a middle muscular coat of involuntary fibers, and an outer serous covering which does not extend over the entire organ.

The **urethra** is a single tube which carries away the urine from the bladder. The orifice of the urethra is guarded by a ring-like muscle which completely closes it when in a state of contraction. In the male this organ is common to the urinary and genital systems, and will be described with the latter. The *urethra of the mare and cow* is about 2 inches long and connects the bladder with the vulva, into the floor of which it opens by the *meatus urinarius*, about a hand breadth from the external opening of the vulva.

THE PHYSIOLOGY OF URINE SECRETION

The secretion of urine is a continuous process. The blood enters the glomerulus of the malpighian corpuscle under pressure, where it meets with opposition to its outflow. Here most of the water and soluble salts found in urine are secreted. The uriniferous tubules are lined with cells capable of extracting from the blood the urinary pigments and solids that were not allowed passage at the expanded end of the tubules. These are flushed out by the fluid from above, and are carried to the pelvis of the kidney by the collecting tubules. In general all statements made in Chap. IV about the process of secretion hold good for urinary secretion. However, the kidneys are unlike most glands in that their secretion pressure cannot be raised above the arterial blood pressure. This is on account of the arrangement of its minute structures.

Urine is the most important excretion of the body. The amount and composition varies with the age of the animal, the character of the food and drink, and the state of metabolism. The average amount voided by the horse in twenty-four hours is about 3000 to 4000 cc., but may be as much as 9000 cc. Experiments with dairy cows show that only about 13 per cent. of the water taken into the digestive canal is passed through the kidneys. When sweat is profusely excreted the urine is proportionately reduced in amount. Urine is alkaline in reaction in herbivora unless the animal is starved, or on a ration composed entirely of wheat plant products or other unnatural feed combinations, when it is uniformly strongly acid. Equine urine has a specific

gravity of about 1035, and is turbid from the presence of the carbonates of lime which it contains.   Bovine urine is clear. A considerable amount of mucus gives fresh urine a sticky feel. The most important constituents are: carbonic, uric, and hippuric acids, and urea, creatin, creatinin, allantoin, and other organic wastes.   Urea and hippuric acid are found in relatively large quantities.   The former comes from protein metabolism and the putrefaction of proteins in the intestines, while the latter is formed chiefly from the benzoic acid in the roughage, and is present in larger amounts upon a ration consisting mostly of hay or grass than of concentrates.

It is obvious that the urine is derived from the blood flowing through the kidneys.   By arranging the various substances found in each of these fluids in tabular form for comparison, it is evident that they differ but slightly in qualitative composition, for the only substance found in the urine and not in the blood is hippuric acid.   However, the quantitative proportion of nearly all the substances varies widely, if refined methods of chemical analysis are employed.

The concentration of the salts of sodium and urea and uric acid in the urine is greater than that of the blood.   Normally the kidneys do not allow any sugar to pass out with the urine. When there is injected into the veins some sodium chlorid solution of the same strength of salt content as is contained in blood itself, a curious effect is observed.   The kidneys become unable to hold back the sugar in the blood so it filters through them and escapes in the urine.   If, however, there is added to the sodium chloride solution some calcium, magnesium, and potassium salts as found in blood, large amounts of the solution can be introduced into the blood stream without causing any disturbance in the function of the kidneys whatsoever.   It is not known why this is, but it has been observed many times, so physiologists have given the term "balanced salt solution" to that solution necessary for the proper functioning of the living tissues.

It is evident from this brief review, that the process of urine secretion is not a simple filtration, as was at one time supposed, but is a vital process involving cellular activity.   Moreover, that the flow of urine will be increased (1) by raising the blood-pressure; (2) by increasing the water content of the blood through absorption from the intestines; (3) by retarding the elimination of fluids

by other channels of the body, like the digestive and respiratory tracts and the skin. When these conditions are reversed the flow of urine will be reduced.

The **function of the kidneys** is, concisely, to elaborate the urine, yet with the exception of hippuric acid, the kidneys do not form the substances urine contains. Their work is therefore mostly to dispose of wastes formed in other parts of the body. They are active in maintaining (1) the concentration of the blood by regulating the salt content; (2) the volume of the blood by regulating the water content; (3) the neutral reaction of the blood by excreting the excess sodium acid phosphate. When the liver fails to function properly the kidneys compensate by eliminating larger amounts of ammonium salts and other waste products than they do normally.

THE PHYSIOLOGY OF URINATION

The process of expelling urine from the body after it has been elaborated by the kidneys consists first, in the flow from the pelvis of the kidney through the ureters to the bladder; second, in the emptying of the bladder. The first act is involuntary and continuous, like that of urine secretion, and is made possible by the rhythmic waves of contraction of the involuntary muscle fibers in the ureters. The emptying of the bladder, true urination, or micturition, occurs periodically through reflex stimulation of the muscles in the bladder wall by impulses received from the *nerve-center for urination* situated in the lumbo-sacral part of the spinal cord. This act is either the result of pressure or irritation in the bladder, or an impulse originating in the brain. Urine retention and expulsion are ordinarily involuntary in animals.

THE REPRODUCTIVE ORGANS OF THE MALE

Starting with the testicles as the central structures of the male genital tract, the following organs are found in succession—the testicles and their covering, the scrotum, the ductus deferens, the seminal vesicles, the prostate and Cowper's glands, and the penis (Fig. 48).

The **testicles** are paired glandular organs situated in the inguinal region. Each has a worm-like appendage of seminiferous tubules

known as the *epididymis*.   They are developed in the sublumbar region, and descend prior to or shortly after birth through the *inguinal canal* into the scrotum.   In the majority of colts
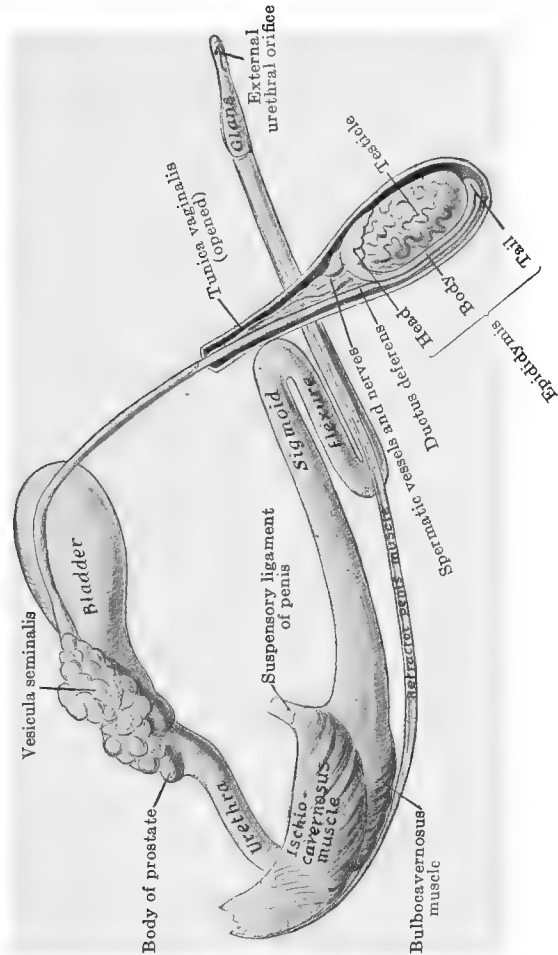
Fig. 48.—General view of genital organs of bull.   (Sisson, Anatomy of Domestic Animals.)

they cannot be felt until the animal is several weeks old.   When either or both testicles fail to pass into the scrotum the animal is said to be a cryptorchid or ridgling.   A serous membrane, the

tunica vaginalis propria, closely envelops the testicle. The testicles secrete the *spermatic fluid* or *semen.*

The **scrotum** is the sac in which the testicles are normally enclosed. It has an outer layer of soft, oily skin, beneath which is a strong fibrous layer. The *tunica vaginalis communis* lines the scrotum. It is a serous membrane, and directly continues the peritoneum, of which it is a pouch-like diverticulum. Between the two vaginal tunics is normally found a potential cavity containing a serous fluid to prevent friction as the testicle changes position.
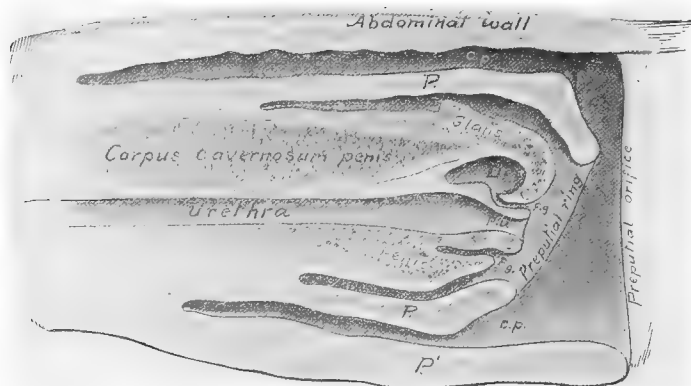
Fig. 49.—Section of prepuce and part of penis of horse: *P*, Internal part of prepuce or prepuce proper; *P′*, external part of prepuce or sheath; *C.p.* preputial cavity; *Fg.,* fossa of glands; *D.* diverticulum; *P.u.,* end or urethra. (Sisson, Anatomy of Domestic Animals.)

The **ductus deferens** is a thick-walled duct, about $\frac{1}{8}$ inch in diameter, which carries away the secretion of the testicle. There is one for each of these glands. It passes upward through the inguinal canal to the abdominal and pelvic cavities. It ends by entering the urethra.

The **spermatic cord** is that mass of tissue which is severed when the animal is castrated. It is composed of the ductus deferens, the blood-vessels, the nerves, and the tunica vaginalis.

The **seminal vesicles** are in contact with the dorsal surface of the bladder. In some animals they serve as reservoirs for the semen. In the bull they are distinctly glandular.

The **prostate and Cowper's glands** lie at the beginning of the

urethra. They secrete fluids which are poured into the latter tube for the purpose of facilitating the passage of the testicular secretion. They also dilute the secretion from the testicles, adding volume to it so that it is more likely to reach the ovum.

The **penis** is largely composed of erectile tissue—the *corpus cavernosum*. The organ extends from the ischial arch, where it is firmly attached, forward between the thighs. It has at the free end a covering of skin, called the *prepuce* or *sheath* (Fig. 49). The inner layers of the prepuce are supplied with large sebaceous glands; the secretion is named smegma. The latter has a tendency to collect in the horse and cause "foul sheath" unless washed out at intervals. When the diverticulum of the fossa of the glans penis becomes filled with smegma, it causes the formation of a "bean," which sometimes materially interferes with urination. The bull's penis has an S-shaped curve (Fig. 48). The penis is the male copulatory organ.

The **urethra of the stallion and bull** is the long mucous tube which extends from the bladder to the lower or anterior end of the penis. It passes backward on the floor of the pelvis, turns around the ischial arch, and then runs forward and downward, embedded in the spongy tissue of the penis. The urethra conveys the urine and the semen.

THE REPRODUCTIVE ORGANS OF THE FEMALE

The *female genital organs* are the ovaries, the fallopian tubes, the uterus, the vagina, the vulva, and the mammary glands (Fig. 50).

The **ovaries** are two in number, and much smaller than the testicles, with which they are homologous. They are situated about a hand breadth behind the corresponding kidney. A fold of peritoneum attaches them loosely to the sublumbar region. Embedded in the fibrous tissue of the substance of the ovary are little masses of epithelial cells from which the *graafian follicles* and eventually the *ova* develop. The functional value of the ovaries is to form the ovum or female reproductive cell.

The **fallopian tubes** are two tortuous passages, about 10 inches long and about $\frac{1}{8}$ of an inch in diameter, that run between the layers of the broad ligaments. The ovarian end of the tube is fringed or fimbriated, and expanded into a funnel-like infun-

dibulum for the purpose of catching the ova when they are discharged from the surface of the ovary. The uterine end joins the womb. Their function is to convey the ova to the uterus.

The **uterus** is a hollow, muscular organ situated in the abdominal cavity, from the walls of which it is suspended by the broad ligaments. It is commonly termed the womb and consists of two horns, the body, and the neck.
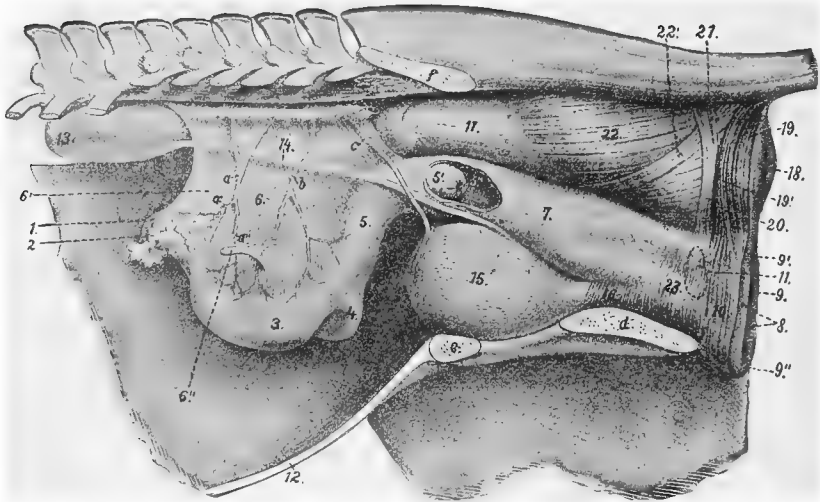
FIG. 50.—Genital organs of mare, lateral view: 1, Left ovary; 2, fallopian tube; 3, 4, 5, uterus; 5′, cervix of uterus, and 5″, os uteri, seen through window cut in vagina; 6, broad ligament of uterus; 6′, round ligament of same; 7, vagina; 8, 9, lips of vulva; 9′ and 9″, commissures of vulva; 10, constrictor muscle; 11, erectile gland; 12, wall of abdomen; 13, kidney; 14, ureter; 15, bladder; 16, urethra; 17, rectum; 18, anus; 19 and 19′, 20, 21, 22, 23, muscles; a, a′, a″, b, c, arteries; d, ischium; e, pubis; f, ilium. (After Ellenberger, in Leisering's Atlas.)

In the mare the horns are about 10 inches long and rounded at the anterior ends. The body is about 6 inches in length and cylindric in shape. The neck or cervix is the constricted part which joins the vagina. In the uterus the fetus is retained and nourished until it is able to maintain a separate existence.

The mucous membrane lining the horns and body of the uterus of the mare is perfectly smooth. That of the cow presents about a hundred uterine *cotyledons* commonly known as "but-

tons," to which the placenta is attached. In the non-gravid uterus they average about $\frac{1}{2}$ inch in length, and a little less in width and thickness. During pregnancy they become greatly enlarged and pedunculated and may measure as much as 5 inches in length.

Fig. 51.—Cross-section of mammary gland of cow: *a*, body of gland; *b*, lactiferous sinus; *c*, cavity of teat; *d*, teat canal; *e*, intermammary groove; *f*, septum between glands; *g*, supermammary fat. (Sisson, Anatomy of Domestic Animals.)

The **vagina** is a tubular organ which connects the uterus and the vulva. It is about 10 inches long, and is lined with mucous membrane thrown up into folds that are effaced when the fetus is passed. The *os uteri* projects freely into the fore part of the vaginal cavity.

The **vulva** is the passage that continues the vagina backward,

and forms the posterior opening of the genital canal. It is about 5 inches long. At its margin the mucous membrane, which lines the entire genital tract, meets the skin. On the floor of the vulva may be seen the external orifice of the urethra. The *clitoris*, a small erectile body, is lodged within the inferior commissure of the vulva.

The **mammary glands** are two in number and placed side by side on the middle line of the abdominal wall between the thighs. The teat or nipple in the mare is perforated by two or three orifices for the passage of the milk. The glands are composed of secreting cells which line minute acini that connect with small ducts. These ducts unite to form a number of tubes which drain into a central sinus or milk cistern. The function of the mammary glands is to secrete milk upon which the foal subsists for some months after birth. In the cow these glands are commonly spoken of as the udder (Fig. 51.) This organ is often very large and pendulous in dairy breeds. Usually it is considered as consisting of two glands divisible into four quarters. Although each gland is separated by a septum, there is no visible division between the two quarters of the same side. However, injections of fluids of different colors into the two teats of the same gland demonstrate that the cavities drained by them do not communicate. The cavity in the center and above each teat is known as the milk sinus.

THE PHYSIOLOGY OF REPRODUCTION

Reproduction may be defined as the power to produce new but similar individuals. It requires the union of the *spermatozoön* from the male and the *ovum* from the female. The female is concerned with the complete reproduction process which consists of the following stages: copulation, impregnation, gestation, parturition, and lactation. The male is concerned only with the first two of these stages.

Puberty is the earliest age at which animals are able to procreate or beget. Animals of both sexes pass through this stage before they are sexually mature. It varies with species, breed, nourishment, and precocity of the individual. In highly fed animals and those with a nervous temperament it appears earliest. Too early stud service may retard the development of the stallion. He may be used on a few mares when two years of

age, but should not be placed in regular service until he is three or four years old. The filly is usually sexually mature when one year old, but should not become a mother until she reaches the age of three years, or four if she is not precocious. This means that it is safe to breed her at two years of age. There is no experimental evidence to support the belief that the long continued practice of breeding immature females will result in decreasing the size of the breed or in the production of more refined types. The capacity to develop to a certain size at maturity is a hereditary tendency and is not influenced in any way by the breeding of young animals.

Estrum, heat, rut, are expressions commonly applied to the period during which the female exhibits a desire to mate. Ordinarily mating will be permitted only during the period of estrum. Estrum usually occurs in the mare between the fourth and the twelfth day after her foaling. The ninth day seems to be the usual time for successful mating. If for any reason she does not conceive at this time, the estrual period returns every twenty-one days and lasts three or four days, except during the winter in some cases. It is attended with characteristic signs of nervous or sexual excitement and swelling of the external genital organs.

When an animal has been safely bred she is said to have conceived. Horsemen usually present the mare to the stallion ten to fourteen days after service, also on the twenty-first day, to determine whether *conception* has taken place; if she refuses to take the stallion it is generally safe to conclude that she has "settled," conceived, or become impregnated.

Impregnation starts a rôle of rapid changes that are of great interest. The fertilized ovum quickly develops by the process of cell division, from a one-cell structure into a mass of cells, which arrange themselves in a definite manner to form three layers—the epiblast, the hypoblast, and the mesoblast. It becomes attached to the mucous membrane of the uterus through the formation of the *placenta*. At the same time the uterus greatly increases in size and functional activity.

The **fetus** is an entirely independent organism. Its circulation and metabolism are quite separate and distinct from that of the mother. As it cannot use its lungs to purify its blood, this function is performed by the mother. The exchange of gases takes place through the placenta. There is no direct connection between

the blood circulating in the vessels of the dam and that of the fetus.

The **fetal membranes** surround the fetus like an envelop and insure protection, nutrition, and union with the mother. They develop early and contain a quantity of fluid to prevent the fetus against sudden changes in temperature and mechanical injuries. During parturition this fluid lubricates the genital canal and expedites the passage of the fetus. There are three fetal membranes, the amnion, allantois, and chorion. The amnion is the inner membrane and is in direct contact with the fetus. The chorion is the outermost. When the fetus is expelled from the womb these membranes may be retained; collectively they are then known as the "afterbirth." A complete description of these structures may be found in works on anatomy, embryology, or obstetrics.

Pregnancy and **gestation** are synonymous terms and refer to the period of time during which the young is developing in the womb. Physiologic pregnancy is the condition that begins with fertilization of the ovum in the fallopian tube and normally ends at parturition when the fetus is born. It is the most remarkable and highly interesting process in nature and exerts important influences upon the mother. Fortunately, nature makes adequate provision for its successful completion. Only when accident or disease interferes does pathologic pregnancy occur.

An animal that has never given birth to offspring is termed nulliparous; one pregnant for the first time is primiparous; one producing a single offspring at a time is uniparous; one producing two at a birth is biparous; and one producing more than two is multiparous.

In the case of twins the fetuses may occupy one or both uterine horns and part of the body of the uterus. When confined to a single horn, one twin usually has the anterior and the other the posterior presentation. If both fetuses arise from the same ovum a common chorion is present, but each has its allantois and amnion. When fetuses develop from different eggs, each has its own chorion. According to some authorities, while there are temporary deviations in the position of the fetus or fetuses in the uterine cavity, during pregnancy they always return to their original normal positions, which is in the long axis of the horns. In the

GESTATION TABLE

Date of service	Date on which animal may be expected to give birth			
	Mare	Cow	Sow	Ewe
Jan. 1.................	Dec. 3	Oct. 9	April 23	May 28
Jan. 6.................	Dec. 8	Oct. 14	April 28	June 2
Jan. 11.................	Dec. 13	Oct. 19	May 3	June 7
Jan. 16.................	Dec. 18	Oct. 24	May 8	June 12
Jan. 21.................	Dec. 23	Oct. 29	May 13	June 17
Jan. 26.................	Dec. 28	Nov. 3	May 18	June 22
Jan. 31.................	Jan. 2	Nov. 8	May 23	June 27
Feb. 5.................	Jan. 7	Nov. 13	May 28	July 2
Feb. 10.................	Jan. 12	Nov. 18	June 2	July 7
Feb. 15.................	Jan. 17	Nov. 23	June 7	July 12
Feb. 20.................	Jan. 22	Nov. 28	June 12	July 17
Feb. 25.................	Jan. 27	Dec. 3	June 17	July 22
March 2.................	Feb. 1	Dec. 8	June 22	July 27
March 7.................	Feb. 6	Dec. 13	June 27	Aug. 1
March 12.................	Feb. 11	Dec. 18	July 2	Aug. 6
March 17.................	Feb. 16	Dec. 23	July 7	Aug. 11
March 22.................	Feb. 21	Dec. 28	July 12	Aug. 16
March 27.................	Feb. 26	Jan. 2	July 17	Aug. 21
April 1.................	March 3	Jan. 7	July 22	Aug. 26
April 6.................	March 8	Jan. 12	July 27	Aug. 31
April 11.................	March 13	Jan. 17	Aug. 1	Sept. 5
April 16.................	March 18	Jan. 22	Aug. 6	Sept. 10
April 21.................	March 23	Jan. 27	Aug. 11	Sept. 15
April 26.................	March 28	Feb. 1	Aug. 16	Sept. 20
May 1.................	April 2	Feb. 6	Aug. 21	Sept. 25
May 6.................	April 7	Feb. 11	Aug. 26	Sept. 30
May 11.................	April 12	Feb. 16	Aug. 31	Oct. 5
May 16.................	April 17	Feb. 21	Sept. 5	Oct. 10
May 21.................	April 22	Feb. 26	Sept. 10	Oct. 15
May 26.................	April 27	March 3	Sept. 15	Oct. 20
May 31.................	May 2	March 8	Sept. 20	Oct. 25
June 5.................	May 7	March 13	Sept. 25	Oct. 30
June 10.................	May 12	March 18	Sept. 30	Nov. 4
June 15.................	May 17	March 23	Oct. 5	Nov. 9
June 20.................	May 22	March 28	Oct. 10	Nov. 14
June 25.................	May 27	April 2	Oct. 15	Nov. 19
June 30.................	June 1	April 7	Oct. 20	Nov. 24
July 5.................	June 6	April 12	Oct. 25	Nov. 29
July 10.................	June 11	April 17	Oct. 30	Dec. 4
July 15.................	June 16	April 22	Nov. 4	Dec. 9
July 20.................	June 21	April 27	Nov. 9	Dec. 14
July 25.................	June 26	May 2	Nov. 14	Dec. 19
July 30.................	July 1	May 7	Nov. 19	Dec. 24
Aug. 4.................	July 6	May 12	Nov. 24	Dec. 29
Aug. 9.................	July 11	May 17	Nov. 29	Jan. 3
Aug. 14.................	July 16	May 22	Dec. 4	Jan. 8
Aug. 19.................	July 21	May 27	Dec. 9	Jan. 13

GESTATION TABLE   *(Continued)*

Date of service		Date on which animal may be expected to give birth							
		Mare		Cow		Sow		Ewe	
Aug.	24	July	26	June	1	Dec.	14	Jan.	18
Aug.	29	July	31	June	6	Dec.	19	Jan.	23
Sept.	3	Aug.	5	June	11	Dec.	24	Jan.	28
Sept.	8	Aug.	10	June	16	Dec.	29	Feb.	2
Sept.	13	Aug.	15	June	21	Jan.	3	Feb.	7
Sept.	18	Aug.	20	June	26	Jan.	8	Feb.	12
Sept.	23	Aug.	25	July	1	Jan.	13	Feb.	17
Sept.	28	Aug.	30	July	6	Jan.	18	Feb.	22
Oct.	3	Sept.	4	July	11	Jan.	23	Feb.	27
Oct.	8	Sept.	9	July	16	Jan.	28	March	4
Oct.	13	Sept.	14	July	21	Feb.	2	March	9
Oct.	18	Sept.	19	July	26	Feb.	7	March	14
Oct.	23	Sept.	24	July	31	Feb.	12	March	19
Oct.	28	Sept.	29	Aug.	5	Feb.	17	March	24
Nov.	2	Oct.	4	Aug.	10	Feb.	22	March	29
Nov.	7	Oct.	9	Aug.	15	Feb.	27	April	3
Nov.	12	Oct.	14	Aug.	20	March	4	April	8
Nov.	17	Oct.	19	Aug.	25	March	9	April	13
Nov.	22	Oct.	24	Aug.	30	March	14	April	18
Nov.	27	Oct.	29	Sept.	4	March	19	April	23
Dec.	2	Nov.	3	Sept.	9	March	24	April	28
Dec.	7	Nov.	8	Sept.	14	March	29	May	3
Dec.	12	Nov.	13	Sept.	19	April	3	May	8
Dec.	17	Nov.	18	Sept.	24	April	8	May	13
Dec.	22	Nov.	23	Sept.	29	April	13	May	18
Dec.	27	Nov.	28	Oct.	4	April	18	May	23

great majority of cases the fetuses of the larger animals are presented head first, although posterior presentations are not uncommon (Fig. 52).

The strain incident to the development of twins is so great in the mare that abortion or premature birth occurs in about 90 per cent. of the cases, or the foals are so weak and small that they fail to thrive.   The cow may have twins, triplets or quadruplets, all of which may be carried full time and develop to maturity.

At no time of life is the growth of the animal nearly so rapid as it is during the period spent in the womb.   Growth of the fetus is more rapid during some stages than others and may be interrupted temporarily by disturbances in the nutrition of the mother.   The length of the fetus is the safest guide in the determination of its age.

The **duration of pregnancy** varies widely with different species, and narrowly with individuals of the same species and with the same individual during different pregnancies. Generally a male fetus is carried longer by a unipara than a female fetus. A well-bred precocious animal usually has a shorter gestation period than does the mongrel, scrub or poorly nourished animal.

The accompanying gestation table, page 153, enables one to calculate when an animal may be expected to give birth to off-spring. Average periods of gestation have been taken in computing the table, that for the mare being 337 days, cow 282 days, sow 113 days, and ewe 148 days.

Average periods of puberty, estrum, and gestation for different species of farm animals are given in the following table. These figures have been compiled from a large number of records. In the case of gestation the shortest and longest are extremes which accounts for the wide difference.

TABLE SHOWING PERIODS OF PUBERTY, ESTRUM, AND GESTATION IN FARM ANIMALS

Puberty			Estrum			Gestation		
Animal	Average age, mo.	Best time to breed, mo.	Duration	Repeats	Occurs after parturition	Short-est, days	Long-est, days	Aver-age, days
Mare..........	10	24–36	3–7 days	3 weeks	3–17 days	287	419	337
Cow..........	10	15–18	3–48 hours	3 weeks	28 days	240	330	282
Sow..........	6	9–10	1–5 days	3–5 weeks	3–9 days	104	143	113
Ewe..........	6	18–20	1–3 days	13–19 days	6–7 mo.*	140	156	148

* Ewes of the Dorset breed come in heat 7–10 days after parturition.

The **phenomena produced by pregnancy** vary in different species. The mare becomes quieter, more docile, and after the third month gradually increases in weight. She usually gains 150 to 200 pounds during this time. Fractured bones unite more slowly on account of the drain by the fetus on the mother's osseous elements. Local changes due to pregnancy occur in all the organs of the genital tract but no new functions are acquired.

Naturally the uterus is most markedly changed. Immediately after conception takes place this organ begins to increase in size and vascularity to accommodate the growing embryo

and to supply it with nutritive blood. The increase in size affects chiefly the gravid horn (except in the case of twins) and the body. The horn attains a length of $2\frac{1}{2}$ to 3 feet in the mare and cow and a corresponding diameter. The uterus at this time weighs about 9 pounds.

The **diagnosis of pregnancy in the mare** is based on a clear understanding of the anatomy and physiology of the genital organs. As there always is danger of making mistakes, especially during the early stages of pregnancy, the veterinarian usually makes a provisional diagnosis unless the signs are well marked.

Objective signs of pregnancy include all those changes that are visible to or may be discovered by the examiner. During the first weeks after conception there are few, if any, observable.

The first sign that strongly suggests pregnancy is failure in the occurrence of the estrual period. It is not an unfailing sign for in some cases estrum recurs after conception has taken place. Some pregnant mares will again receive the stallion.

After the third or fourth month the mare shows a more thrifty appearance, as a rule, by growing a sleeker coat and putting on flesh. Not until the sixth month of the gestation period, or later, is there an appreciable increase in the size of the abdomen. About 25 per cent. of pregnant mares fail to exhibit this sign until other more reliable signs are noticeable.

An unfailing sign is the general enlargement of the udder. This begins about six weeks before foaling time and is more noticeable in the morning. By noon, if the mare has had exercise, the swelling disappears.

The secretion of colostrum and the formation of wax at the teat orifices are other signs, but they do not occur until late in the gestation period. When taken alone these changes of the animal are not positively diagnostic and their absence does not disprove pregnancy, yet they are more reliable than most others.

Movements of the fetal limbs and body are audible and palpable after the mare has had a large draught of ice cold water. They even may be seen by the eye after the seventh or eighth month. To detect fetal movements the left ear should be placed against the abdomen, just below the left flank and some eight or ten inches in front of the stifle. When the hand is used, the

same place is selected and continuous pressure exerted to detect a hard, irregularly moving mass in the uterus.

Palpation of the uterus through the rectum or vagina is a means of determining the existence of the fetus after the fifth month. Before this time the fetus may be so small as to escape detection, especially in large mares. Experience in manipulating the genital organs is essential to the success of this operation.

Well toward the end of the gestation period the vulva swells and the vaginal mucous membrane is greatly congested. A few hours before parturition the lips of the vulva are considerably swollen and gape apart. The mare becomes restless, ceases to eat, switches, lies down, rises, and the labor pains in due time effect expulsion of the fetus.

Subjective signs of pregnancy consist of those things that are appreciable by the affected individual alone. Domestic animals exhibit only a few of these signs. Pain produced by the violent movements of the fetus is the most common; it causes the mare to switch, bite at the flank, and kick at the belly.

In 1913 Abderhalden perfected a test to determine the presence or absence in the blood serum of ferments capable of digesting placental albumins and believed to be produced only during pregnancy. It is not a test for pregnancy, but demonstrates certain substances produced as a result of this condition. The test is strictly a laboratory procedure and requires a careful, well-trained technician for reliable results. Zell reports that he has made nearly 400 tests with results that checked closely with other tests. Blood samples drawn as early as the second and third week after assumed conception were as satisfactory as those drawn later.

The **effect of pregnancy** is popularly supposed to be a serious drain on the system, due to the fact that a large supply of nutrients is essential for the development of the unborn young in the uterus. Recent investigations indicate that pregnancy does not exhaust the mother. In fact young pregnant animals grow normally during this period without great additional increase in food supply, one reason for this being that the fetal tissues are largely composed of water. During the period of lactation, however, growth may be interfered with or even stopped altogether. The conclusion is that dwarfing in the young mother

results from the strain of lactation rather than from the effect of gestation.

Normal parturition is the act of giving birth to the fetus (now called the foal, calf, lamb, or pig).   When occurring in the mare it is designated foaling; in the cow, calving; in the ewe, lambing, and in the sow, farrowing.   The following *signs of parturition* may be evident a week or more before parturition occurs.   A straw-colored fluid oozes from the teats of the swollen udder, where it
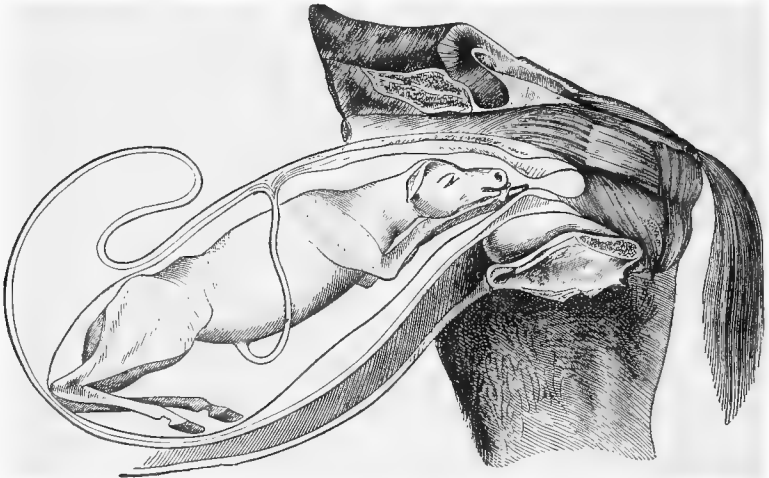
FIG. 52.—Position of fetal foal at parturition.   The normal, anterior presentation with the fore feet and head entering the genital canal.   (Fleming.)

dries and forms a wax-like mass over the orifices of the teat.   The milk secretion sets in and may become so profuse that it drips from the teats or escapes in a stream.   The mouth of the womb dilates; the lips of the vulva become swollen, congested, and stand apart; the mare becomes uneasy and nervous as a result of the onset of labor pains; the "water bag" or amnion filled with a clear fluid appears.   Under normal conditions foaling is accomplished rapidly and with but slight discomfort to the mare.

The fetus should normally come with the fore feet first and the nose between the knees (Fig. 52), or may have the hind feet presented first.   In either case it is wise to let nature take her course and not interfere, even if the process seems to be unusually

slow. Shortly after the young is born its surrounding membranes, known as the "after birth" or placenta are usually expelled. Generally retention of the placenta should always be regarded as a sign of trouble and steps taken to facilitate its removal.

The **hygiene of the pregnant mare** is an important factor in insuring a healthy foal. Care should be taken to so feed, exercise, shelter, and manage the mare that her foal at birth will be strong, fully developed, and enabled to resist disease.

With these objects in view, work the mare lightly or give her ample exercise every day. Provide for her a clean, dry, well-bedded, and roomy box stall when in the stable so that she may have opportunity to exercise, to escape being "cast" or getting "stocked legs," and to prevent the occurrence of dropsical swellings of the udder and abdomen.

In Circular 61 of the Wisconsin Argricultural Experiment Station Dr. A. S. Alexander says to feed the mare generously on sound, whole oats, corn, wheat bran, and clover, mixed clover, or timothy hay. Add roots to regulate the bowels. Avoid moldy. hay or silage, damaged grain, woody, weathered corn fodder, dusty or rusty straw and hay containing poisonous plants. Keep her out of corn stalk fields. Provide plenty of pure, clean drinking water. Prevent drinking of surface or pond water. Do not jerk or strain the mare by hard pulling or wading through deep mud, snow drifts, or manure piles. Treat her kindly and gently and let her work be light, easy, and steady.

When foaling time approaches reduce the grain ration and increase the laxative food. Stop working the mare and place her in a specially prepared box stall at the beginning of the last, or forty-eighth week of pregnancy. The dimensions of the box stall should be 12×12 or 14×14 feet. The larger size stall is preferable. It should be well lighted, properly ventilated, and made ready for occupancy by the mare in the following manner: Remove all litter and manure. Cleanse and scrape the floor; then saturate it with a mixture of one part of coal tar disinfectant and fifty parts of water. Scrub and cleanse the walls with a similar solution, or a solution of one part of corrosive sublimate (mercuric chloride) in one thousand parts of water; then apply freshly made limewash to the walls and ceiling. Cover the floor with fresh, dry, clean straw that is free from chaff and dust, or

with planing mill shavings. Keep the bedding clean and dry by promptly replacing portions soiled by manure or urine.

When labor pains start, leave matters to nature if the position of the foal is normal. Avoid too early interference as it may prove disastrous. If anything seems wrong send for a veterinarian. Allow the mare to rest for a time if lying down after foaling. When she rises, or half an hour after foaling, if she is up, and again at intervals of two hours, offer her a pailful of lukewarm water. Feed her a bran mash an hour or so after foaling, if she is accustomed to such feed, otherwise allow her a small feed of her ordinary grain ration. If the afterbirth does not come away promptly, it should be removed by the attending veterinarian, who will employ antiseptics to prevent infection and consequent inflammation of the womb (metritis) and "colt founder" (laminitis).

Turn the mare on grass for a short time, if the weather is fine, a day or two after foaling, but do not allow the foal to lie down and become chilled Gradually lengthen the time on grass daily and get the mare onto full feed, unless she has more milk than the foal needs, in which case it will be well to withhold extra feed. Return her to light work in from ten days to two weeks.

Lactation is the process in which the udder secretes and yields milk. The term is also applied to the period during which milk is secreted. The period of lactation follows parturition and normally continues until the offspring is weaned. When milked daily, animals have continued to produce milk for several years. Most animals produce a larger amount of milk if they have reached maturity before lactation begins.

The secretion of milk is a feminine characteristic, nevertheless at birth the mammary glands of both sexes are very similar. Milk is produced in little cells that are broken down by the suckling or by the hand of the milker. The fluid is discharged into the milk cisterns at the bases of the teats.

Growth of the mammary glands is largely controlled by the ovaries. If these organs are removed before puberty, mammary gland development and other secondary sexual characteristics are repressed.

That there is an intimate relationship between the activity of the mammary glands and the generative organs there can be little doubt. A worker in Starling's laboratory injected an extract

of fetal tissues into the body of a virgin.   This caused the mammary glands to become active and secretion of milk was actually produced.   The experiment shows that in the fetus there is some substance, or property, which has a direct action upon the mammary tissue.

Milk is the food best suited to the needs of the newborn.   It is readily digested and assimilated by both the intestines and the body cells of the young animal.   The principal reasons why it is better than other foods for the young are that it contains a uniform mixture of the inorganic salts and the essential organic nutrients, especially adapted to the growing organism and little change takes place in it from day to day.

11

THE NERVOUS SYSTEM

THE STRUCTURE OF NERVOUS TISSUE

A **nerve**, as seen in a piece of flesh, consists of an elongated cord made up of bundles of nerve-fibers and having the property of transmitting impulses. It may be compared to the cable, composed of many thousand wires, of a telephone system. When studied with the aid of a microscope the **nerve-fibers** are found to be very delicate structures. They are of two kinds. The *medullated nerve-fibers* are fine filaments surrounded by a thick, white medullary sheath. This sheath is not continuous, but is interrupted at regular intervals so as to expose the fiber. The neurilemma is a thin sheath directly surrounding the nerve-fiber and its medullary sheath. Medullated nerve-fibers are found in the nerves of the cerebrospinal system. The *non-medullated nerve-fibers* have only the neurilemma for a covering. They occur principally in the sympathetic nerve-trunks and plexuses.

The **nerve-cell**, or neuron, is the unit from which the nervous system is built. It consists of a large, irregular, nucleated cell-body that gives origin to one or more fine tapering processes. These **nerve-processes** are of two kinds—the axon, or axis-cylinder process, which becomes the nerve-fiber previously described; dendrites, or protoplasmic processes, which branch out to bring the nerve-cell into definite relationship with others (see Fig. 2). The axons of nerves in some organs are extremely short, while in the limbs they reach from cells located in the spinal cord to the foot. The cell-bodies lie in the gray matter of the spinal cord, brain, and ganglia.

Nerve ganglia are hard, grey masses found on the dorsal roots of all spinal nerves and along the course of some other nerves. They are composed of groups of cell-bodies.

Nerve-endings differ materially in arrangement depending on location. Examples of sensory nerve endings are the retina of the eye and the auditory nerve of the ear. The muzzle contains highly developed nerve terminations.

Nerve-substance is of two distinctly different kinds as may be seen with the naked eye when a cross section of the spinal-cord or brain is made. The *white matter,* which is composed mostly of nerve-fibers closely packed in parallel bundles, is soft and contains about 70 per cent. of water; the *gray matter* which consists largely of nerve-cells, is brown in color and of even softer consistency than the white substance, containing over 80 per cent. of water. There is a decided difference in opinion among histologists in regard to the finer features of the gray matter.

THE ORGANS OF THE NERVOUS SYSTEM

The organs comprising the nervous system may be arranged under the following subsystems: (1) the *central nervous system,* comprising the brain and spinal cord which are encased by bones; (2) the *peripheral nervous system,* comprising the 12 pairs of cranial and forty-two pairs of spinal nerves with their ganglia which are distributed throughout the various organs of the body; (3) the *sympathetic nervous system,* comprising two chains of ganglionated nerve cords extending on either side of the lower surface of the thoracic vertebræ and their various branches to all the soft organs of the large body cavities. These three systems of nerves have intimate relations with each other by means of connecting fibers.

The **brain** is the chief organ of the central nervous system (Fig. 53). It is located in the cranial cavity, and is composed of the cerebrum, the cerebellum, the pons, and the medulla ob-longata. Completely enveloping these parts and continued onto the spinal cord, with which the brain is connected, are three membranes or meninges (Fig. 54).

The **dura mater** is the most external of these membranes. It is a thick, tough, fibrous covering, bluish white in color. It lines the cranial cavity and extends backward to form a tube-like sheath for the spinal cord.

The **arachnoid** is the middle coat. It is a delicate, serous membrane. Between its two layers is a space containing the cerebro-spinal fluid. This fluid acts as a sort of water-jacket to take jar and pressure off the sensitive nerve structures which it encloses.

The **pia mater** closely covers and adheres to both the brain and spinal cord. It contains numerous small blood-vessels for these structures.

The **cerebrum,** or large brain, occupies the anterior part of the cranial cavity. It is somewhat egg-shaped in the horse, and is divided by a deep median fissure into two hemispheres. Ex-
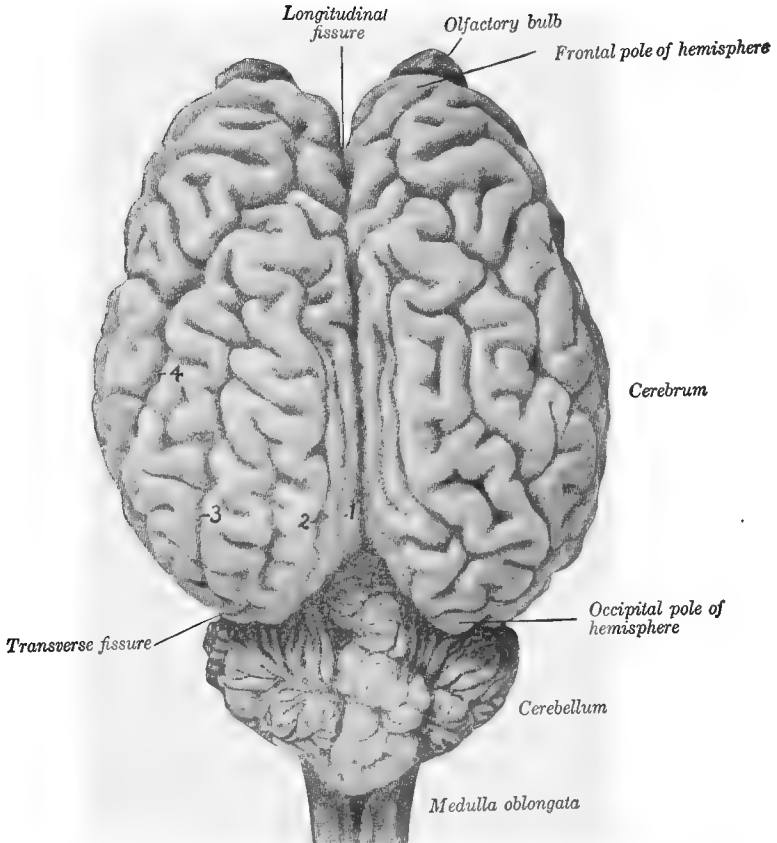
FIG. 53.—Dorsal view of brain of horse. (Sisson, Anatomy of Domestic Animals.)

ternally, the surface is thrown up into well-defined convolutions. The outer part is composed of gray matter. In the center is found a core of white matter. An irregular cavity, termed the lateral ventricle, may be seen in the interior of each hemi-

sphere. The olfactory bulb is the enlargement which projects from the frontal pole of the hemisphere.

The **cerebellum,** or small brain, is lodged in the posterior fossa of the cranium. It resembles a globe in shape and differs from the cerebrum in having a finer marked exterior. It is divided into the median vermis and two lateral hemispheres. For the most part it is composed of gray substance, but a core of white material resembling the branchings of a tree may be seen when the cerebellum is sectioned.

The **pons** (Varolii) is a bridge-like affair, which lies between the medulla and the cerebral peduncles. It connects the former with the cerebrum, and also the right and left portions of the cerebellum.

The **medulla oblongata,** or bulb, is the connecting link between the pons and the spinal cord. It differs from the brain proper in having the white substance externally.

The **cranial nerves** arise directly from the brain. They are of very unequal size and emerge through openings in the skull. There are twelve pairs, which have been numbered and named to identify them. The names indicate the functions or the parts to which they pass.

The *first* or *olfactory nerve* supplies the mucous membrane of certain portions of the nasal cavity and has to do with the special sense of smell.

The *second* or *optic nerve* furnishes the eyes and has to do with the special sense of sight.

The *third* or *oculomotor nerve* supplies all except two of the muscles of the eyeball.

The *fourth or trochlear nerve* is the smallest of the cranial nerves. It ends in the posterior parts of the superior oblique muscle of the eyeball.

The *fifth* or *trifacial nerve* is the largest of the series. It has both motor and sensory fibers for different parts of the face and mouth and has a very important function to perform.

The *sixth* or *abducent nerve* supplies the retractor muscles of the eyeball.

The *seventh* or *facial nerve* is responsible for the movements of most of the muscles of the face. It consists of both motor and sensory parts.

The *eighth* or *auditory nerve* goes to the ear, and has to do with the special sense of hearing.

The *ninth* or *glossopharyngeal nerve* is mixed in character, and conveys both motor and sensory impulses to the tongue and pharynx.

The *tenth, vagus* or *pneumogastric nerve,* is a very large nerve-trunk with both motor and sensory fibers that supply the stomach, heart, lungs, trachea, pharynx, and related organs.

The *eleventh* or *spinal accessory nerve* has motor fibers only.

The *twelfth* or *hypoglossal nerve* is purely motor and innervates the muscles of the tongue.

The **spinal cord** is situated in the vertebral canal, and extends from the medulla, which it continues, to about the middle of the sacrum.   The cord is enlarged where the nerves to the limbs are connected.   On cross-section a dorsal median septum and a ventral median fissure are seen, also the central canal of the cord (Fig. 54).   White matter surrounds a core of gray matter.   The latter is arranged in the form of a capital H.   Dorsal and ventral gray horns, which give rise to nerve-roots with the same names, are plainly visible.

The **spinal nerves** number forty-two pairs.   They take origin from the spinal cord and leave the vertebral canal through the intervertebral foramina.   Each is connected to the cord by a dorsal and a ventral root.   On the dorsal root is found the *spinal nerve ganglion* composed of nerve cells.   These cells are sensory in character and bipolar, that is, have two branches, one to the periphery and one to the spinal cord.   The nerves of the ventral root are motor in character, having no ganglia, their cells being located in the spinal cord.   It is evident that a spinal nerve, beyond the point of union of its two roots, is mixed in character, containing both sensory and motor fibers.

The **sympathetic nervous system** is composed of two chains of ganglia which are located one on each side of the vertebral column, external to the spinal canal.   The nerve-fibers of this system come from the sensory nerve-roots of the spinal nerves. At intervals communicating branches join it with the central nervous system.   There are special ganglia and plexuses for the main groups of visceral organs.   The most important is the **solar plexus,** which is situated on the dorsal wall of the abdominal cavity in contact with the aorta.

THE PHYSIOLOGY OF THE NERVOUS SYSTEM

The **work of the nervous system** is to generate and to conduct nerve impulses. It is divided between the central, peripheral and sympathetic subsystems according to their adaptations.

The **functions of the nerve-cells** are of two kinds. They act as a controlling center of the nerve-fibers proceeding from them. They are acted upon by stimuli conducted to them from without
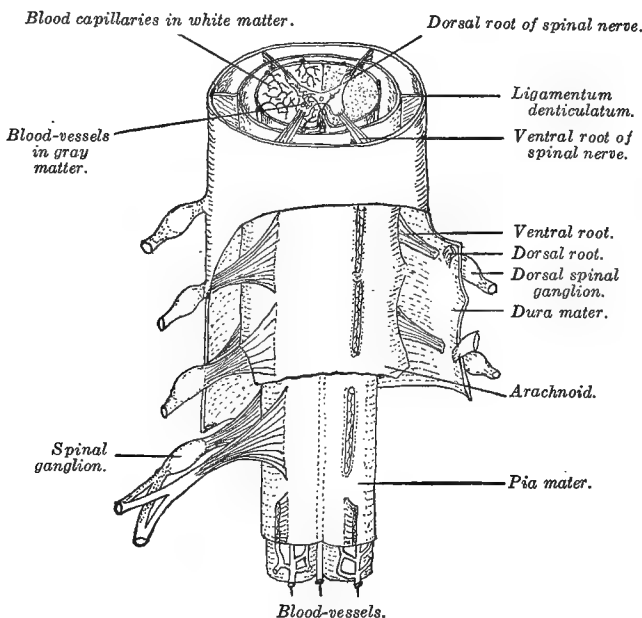
FIG. 54.—Portion of spinal cord and membranes dissected. (Hill's Histology.)

by the nerve-fibers. In the absence of such stimulation they have the power of independent or automatic action. The nerve-cells are also responsible for maintaining the axons in normal condition for when the latter are cut off from the cell body they die.

The **function of the nerve-fibers,** according to Starling, is simply that of conducting impulses from the sense organs at the periphery to the central nervous system and transmitting efferent impulses from this to the muscles and other of its servants.

In order to perform its function the nerve-fiber must have direct continuity with its nerve-cell.

The rate of conduction of the impulse along a nerve-fiber, although very rapid, may be measured by an especially designed electromagnetic apparatus. A nerve of a certain muscle is stimulated at two points a known distance apart, and the time which elapses between the contraction of each is determined. Many measurements have demonstrated that an impulse passes along a nerve at a rate exceeding 100 feet in a second; so the longest paths in the body are traversed almost instantaneously.

The direction in which a nerve-fiber conducts may be determined by either cutting it or stimulating it and noting the result of the stimulation. A nerve can conduct impulses in only one direction, viz., either to the center or to the periphery. Nerves which conduct impulses from the central nervous system outward are termed efferent nerves. They always belong to the ventral nerve-roots of the spinal cord. Nerves conducting in the opposite direction are known as afferent nerves and belong to the dorsal roots of the gray matter of the spinal cord.

Efferent nerves transmit impulses from the nerve centers to the muscles, glands, and blood-vessels. They may either increase the activity of the parts which they supply or diminish activity. Nerves which perform the former kind of work are termed augmentor nerves; the latter, inhibitory nerves.

Augmentor nerves are divided into the *motor nerves*, which act on muscles; *secretory nerves*, which act on secretory glands; *vasoconstrictor nerves*, which narrow the lumen of the blood-vessels. **Inhibitory nerves** are divided in a manner similar to the above into *musculo-inhibitory*, *secreto-inhibitory*, and *vaso-inhibitory nerves*.

Afferent nerves conduct impulses from the outer parts of the body to the central nervous system. They are divided into *sensory nerves*, which when stimulated cause sensations, and *excito-reflex nerves*, which give rise to the so-called reflex actions. These two are not distinct from each other, for at one time they will cause a sensation and at another time a reflex action without sensation.

A sensation is the consciousness that an afferent nerve has been stimulated. Sensations are of various forms; important ones are the sensations of heat, cold, hunger, thirst, taste, smell,

and fatigue. Although the different sensations must be regarded as dependent on the integrity of the brain, they arise from some other part of the body. Lack of space forbids a discussion of each sensation, but those of hearing, sight, and touch will be discussed in Chapter IX. It is important to understand that all sensations are made possible by a perfectly arranged sense mechanism.

A **sense mechanism** is composed of a sense-organ, or sensory nerve-ending, adapted to receive; a path of afferent and efferent nerve-fibers adapted to conduct; either an area in the brain, or a nerve-center in the spinal cord, adapted to interpret.
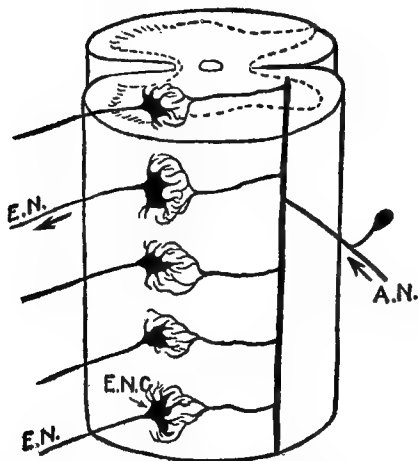
Fig. 55.—Diagram to show the simplest possible basis for a reflex action: *A.N.*, afferent nerve; *E.N.C.*, efferent nerve cells; *E.N.* four efferent nerves. Four synapses are shown at the points where the dendrites of the afferent and efferent nerves connect.

A **voluntary action** of the simplest kind is produced in response to the will or emotions. For its consumation there must be an adequate external physical stimulus; conduction of the stimulus to the central nervous system; transmission of an impulse to the muscles, which produce the end effect.

A **reflex action** is one produced independently of the will in response to an external stimulus. It is always of a distinctly purposeful character, and is made possible by the junction of

two units in the spinal cord. The winking of the eyelid in response to excitation of its sensitive retina or cornea well illustrates a reflex action. The sense mechanism involved consists of sensory nerve endings and fibers, to receive and conduct to the spinal cord; the cross-over or synapse between the dendrites of the sensory and motor nerve cells, to transmit; motor fibers to carry the impulse to the muscles (Fig. 55).

The **synapse** is composed of the fine fibrils of the central branch of afferent nerve cells. The central branch divides on entering the spinal cord into an ascending and a descending branch, each of which runs for a longer or a shorter distance in the white matter of the cord. These branches give off at right angles to themselves collaterals, each of which enters the gray matter and ends there by breaking up into fine fibrils to form the synapse.

It is a common error, according to Hough and Sedgwick, to suppose that all actions which are not called forth by the will are reflex. The essential feature of a true reflex is the more or less direct action of the afferent impulses on efferent nerve-cells, and not merely its non-volitional character. There are, in fact, involuntary actions in which the efferent nerve-cells are directly stimulated not by afferent nerve-cells, but by the condition of the blood or in other ways. Such actions are not reflex, though they may be either involuntary or unconscious, or both. They are known, in general, as **automatic actions.**

The brain, according to Crile, responds to but one stimulus at a time, although it acts with such rapidity and has such capacity for quick changes that it appears to be capable of inducing a number of acts simultaneously. If all the ceptors of the body could be stimulated at one time, the brain would send out first an impulse to the muscles concerned with the action that has proven most important to the survival of the species. In other words, the stimulus which secures possession first of the transmission path is always the stimulus which in the history of the species (phylogenetically) is the most important. For example, stimuli threatening life would take precedence over those presaging slight physical discomfort. Thus a horse would respond to a heavy blow before he would to a bite of a fly if these two stimuli were received simultaneously.

The **function of the cerebrum** is to govern both consciousness and intelligence. Actions are originated and directed by it.

Removal of this portion of the brain does not interfere with eating or sleeping, but the animal cannot associate its sensations. There are certain areas which can be mapped out on the cerebrum of the dog for movements of the eye, the vocal cords, and movements in response to commands. The human brain has been mapped out in great detail, with results which show that the intricacies of it are almost beyond conception.

The **function of the cerebellum** is to act as the center for nerves of coördination, for example, those in the semicircular canals of the ears, the muscles, the tendons, and the joints, all of which are concerned with movements and postures of the body. When its physiologic activities are interfered with the animal reels when it moves and acts as if intoxicated. A serious injury to the cerebellum may cause the patient to walk or spin around in a circle or turn somersaults. Coördination is the combination of work of different muscles in orderly, harmonious action. It is dependent upon the sending out of impulses over the dendrites of afferent nerves to those of efferent nerves. The latter control muscles whose actions are necessary to adjust the movement as a whole.

The **functions of the pons and medulla** are closely related and play a most important part in the economy of the body. These organs are remarkable for the great number of reflex centers they contain—centers for the heart movements, respiration, swallowing vomiting, for closure of the eyelids, and for other actions are located in these portions of the brain. Pithing to destroy life is performed by mutilating this part of the nervous system. The medulla also acts as a great conductor of impulses to and from the higher parts of the brain and the spinal cord.

The **functions of the spinal cord and spinal nerves** are varied. With the exception of a part of the face all of the body is endowed with sensory nerve-fibers from the spinal cord. The nerve-fibers of the ascending and descending tracts in both the white and gray matter of the cord conduct sensations to and from the brain, and, in conjunction with the spinal nerves, from one part of the body to other parts. This latter function is dependent upon the reflex centers which are located at different points in the spinal cord. In the lumbar region there are special reflex centers for impulses from the bladder, rectum, and the sexual organs. The functions may be demonstrated by removing the

brain from a frog. In such an animal all movements are purposeful, but are without intelligent direction. The animal is incapable of originating actions, but can perform reflex actions. Thus, it may be said that the spinal cord converts afferent into efferent impulses; it also serves as an independent nervous center from which purposeful movements are originated.

The **functions of the sympathetic system** are of two kinds: First, it serves to transmit stimuli to the heart and other involuntary muscles and glands. Second, it conducts impulses from the viscera to the cerebrospinal system under which it normally works. In an emergency it has the ability to work independently of the central nervous system to carry out peristaltic movements in the hollow viscera. The sympathetic system is not to be regarded as a separate nervous system but as an outlying part of the cerebrospinal system, through which some fibers from each spinal nerve pass on their way to the viscera.

THE EAR, THE EYE, THE SKIN, AND THE FOOT

THE EAR

The *ear* is the organ that has to do with the sense of hearing. It is subdivided by anatomists into the external ear, the middle ear, and the internal ear.

The **external ear** comprises three cartilages, the largest of which is the trumpet-shaped conchal cartilage which determines the shape of the ear and is covered by thin skin. The annular cartilage is bent to form a tube which is connected with the osseous tube noticed on the temporal bone. Wax or cerumen is secreted by glands in this part of the ear.

The **middle ear** is called the drum on account of the thin tympanic membrane like a drumhead which separates the tympanic air-containing cavity from the external ear. The tympanic membrane vibrates in response to the vibrations in the air which come in contact with it. Across it a chain of three bones is stretched. These bones transmit the vibrations of the tympanic membrane to the inner ear. The bones are named the malleus, from its resemblance to a hammer; the incus, which is shaped like an anvil; the stapes, which is stirrup shaped. A connection is made between the middle ear and the pharynx by means of the eustachian tube to equalize the pressure of air upon the drumhead. In solipeds a diverticulum known as the guttural pouch is found on the course of this tube.

The **internal ear** is composed of soft structures, fluids and a series of chambers in the substance of the temporal bone. In it are found the ramifications of the auditory or eighth cranial nerve, which has to do with the reception of sound-waves. Although the actual organ of hearing is the cochlea, a bony structure similar in shape to a snail's shell, the impulses must be carried over nerve fibers to the brain for interpretation.

The **function of the ear** is to record the sensations of sound. When sound-waves reach the ear-drum they set it in motion. In turn, the latter causes the chain of ossicles to vibrate, and the

173

auditory nerve transmits the impulses to the auditory center of the brain. The maintenance of equilibrium is largely centered in the mechanisms of the internal ear.

THE EYE

The *eye* is the organ of vision. It comprises the eyeball, the optic nerve, and the accessory structures—the eyelids, the conjunctiva, and the lacrimal apparatus.
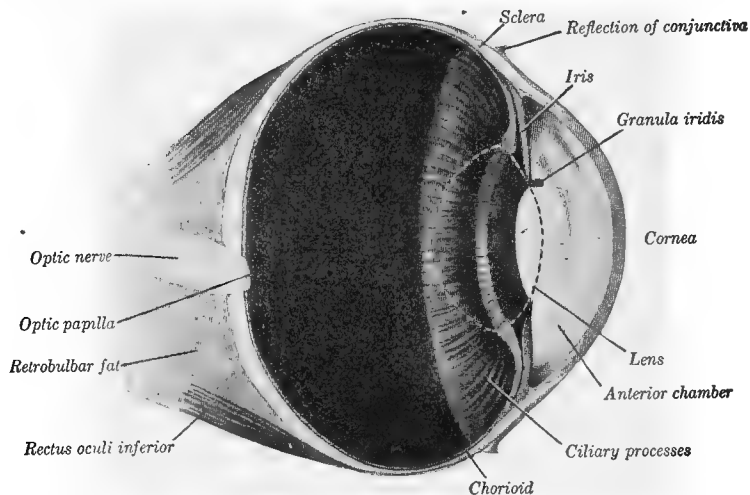
FIG. 56.—Vertical section of eyeball of horse. The contour of the crystalline lens is dotted. (Sisson, Anatomy of Domestic Animals.)

The **eyelids** are the most exposed parts. They are movable folds of skin on the margins of which the eyelashes are borne. The *third eyelid, haw, or nictitating membrane* is an important part of the eye of the horse. It consists of a plate of cartilage covered by a fold of the conjunctiva. By frequently closing and opening the eyelids foreign particles are removed from the exposed parts, thus keeping the eye in working order.

The **conjunctiva** is the mucous membrane which lines the eyelids and is reflected on to the anterior part of the eyeball. It is normally moist and of a bright pink color.

The **lacrimal apparatus** is made up of the *lacrimal gland,* which secretes the tears; and the *lacrimal duct,* which carries

the overflow of fluid to the nasal cavity.   Tears assist in removing the small particles of dirt from the eyeball and keep it moistened.

The **eyeball** is composed of the segments of two spheres of different sizes (Fig. 56).   The anterior is the cornea; the posterior, the sclera.   The *cornea* is transparent, oval in outline, and fits into the sclera like a crystal does into a watch.   The *sclera,* or white of the eye, is the thick, tough membrane which supports the *choroid,* or colored layer, the *ciliary body,* and the *iris.*   At the free margin of the iris is formed the *granula iridis,* "soot ball," or corpora nigra, which is relatively large and easily seen in the eye of the horse.   The opening in the iris is the *pupil.*

The **chambers of the eye** are two in number.   The *anterior chamber* is enclosed in front by the cornea and behind by the iris.   The *posterior chamber* communicates with the anterior through the *pupil* or opening in the iris, and is much the smaller. An *aqueous humor* of clear, water-like consistency fills these chambers.

The **refractive media of the eye** consist of the *vitreous humor,* a semifluid, transparent substance occupying about four-fifths of the whole interior of the globe; and the *crystalline lens,* a biconvex structure composed of concentric layers of tissue.   The latter is situated just behind the pupil.

The **optic nerve** enters the eyeball from the rear and expands to form a very delicate and extremely sensitive membrane known as the *retina.*

The **function of the eye** is to form an image in its fluids so that the animal may better adjust himself to his surroundings.   The retina is the sensory surface which responds to stimulation by light.   The image is upside down, but this fact is of little consequence for it is as easy for the animal to become accustomed to seeing things one way as another.   Any impulses which it receives are transmitted by the fibers of the optic nerve to the visual center in the cortex of the brain.   The iris regulates the amount of light which passes to the retina by dilating and contracting the pupil.   The refractive media are for the purpose of bringing rays of light to a focus on the retina.   The power of accommodation, by which it is possible to see objects at close range as well as at a great distance, lies in the lens, which is flattened or made more convex depending upon whether the object is at a distance

or near at hand.   Each eyeball is afforded varied combinations of movements by special voluntary muscles that are capable of perfectly balancing the eyes for binocular vision.

By cutting the optic nerve total blindness is produced, although light passes through the refractive media of the eye to the retina. This is because the path of conducting nerve-fibers is no longer capable of conducting impulses to the brain and there is no consciousness of stimulation at the nerve ending.

As all are more or less familiar with the parts of a camera, we may compare the eye with a camera and so learn the parts and functions of each part of the eye.   The outermost structures of the eye, as has been stated, are the lids which correspond to the shutter of a camera and completely shut out light from the eye when closed.   Just behind the lids is found the cornea, which is represented in the compound camera by the front lens.   Behind the cornea is the aqueous humor, a structure which has no counterpart in the camera.   The iris with its central opening, the pupil, is represented in the camera by the diaphragm; in both the eye and camera it regulates the amount of light that passes by "cutting down" or "dilating" the aperture.   On a bright day in winter when the sun reflects intense light from the white snow into the eyes, the pupil of the eye becomes very small so as not to allow the rays to flood the back chamber of the eye and injure the sensitive structures located there.   The same is true of the camera—on an extremely bright day the size of the opening in the diaphragm is greatly reduced, to cut down the amount of light admitted and prevent over-exposure.   Immediately after passing through the pupil, the light rays strike the crystalline lens which refracts or bends them and brings them more closely together as does the back lens in a camera.   They then pass through the vitreous humor, which may be compared with the air in the bellows of the camera, but is unlike the latter in that it is a refractive medium.   The walls of the fundus of the eye are darkened by the choroid or middle coat to absorb light, as are the walls of the bellows.   The choroid is supported by the sclera, which in the camera is represented by the case. The retina, or expanded end of the optic nerve, corresponds to the sensitive plate or film of the camera, on which an inverted image of the object is made.

Both the eye and the ear have been called *distance receptors*

from the fact that they bring the body into communication with objects which may be long distances away.

THE SKIN

The *skin* is the covering tissue which acts as a mechanical protection to the surface of the body. On the back of horses and cattle it is $\frac{1}{4}$ inch thick and very strong; on the face it is nearly as thin as paper. It consists of two main layers, the epidermis or scarf skin being the outer, and the dermis or true skin the inner. The **epidermis** is composed of several layers of cells; the outer of these cells are horny, scale-like, and fall off in the form of dandruff when horses are groomed. It contains the coloring-matter or pigment of the skin. The **dermis** is a vascular structure containing a network of white fibrous tissue with some elastic fibers. Its inner face adheres closely to the stratum of fatty tissue which lies beneath it. Its external face is perforated by openings for the hairs and the ducts of the sebaceous and sweat-glands, which lie in the lower layers of the dermis.

In health the skin feels pliable and elastic, and is easily movable upon its underlying tissues. When a fold is drawn up between the fingers, it quickly regains its normal position when released, unless the animal is old or in a state of poor nutrition.

The **sebaceous glands** have small openings into the hair follicles. They secrete an oily substance known as *sebum*, which serves to keep the hair glossy and the skin soft and pliable.

The **sweat** or **sudoriparous glands** discharge sweat directly upon the surface of the skin. They are more than 3,000,000 in number. They occur over the entire surface of the horse's body, but are confined to certain areas in some animals. *Sweat* is a watery fluid, salty to the taste, of strong alkaline reaction, and characteristic odor. Besides water it contains inorganic salts, fatty acids, and waste products. It serves to keep the skin moist and in good condition, to remove waste and poisonous or irritating matters, and to regulate the body temperature by evaporation. In order to keep the skin "pores" from clogging up, the skin should be groomed daily and washed occasionally, otherwise it will become dry, hard, and thick.

The **appendages of the skin** comprise the hair, the chestnuts and ergots on the legs, the hoofs of the feet, and the horns.

Hair is a modification of the epithelium and covers all parts

12

of the body except the muzzle, lips, teats, and genitals. It prevents rapid radiation and conduction of heat. Each hair has a bulbous root springing from the hair follicle, an involution in the skin, into which one or two sebaceous glands empty. Involuntary muscle-fibers are found at the base of the hairs, which cause them to rise or "stand on end" under the influence of cold and excitement. Hair grows by constant additions from the skin to which it is firmly attached. The growth is regulated by the breed and care of the animal. The hair coat of the horse is changed twice a year, once for a heavy and once for a light coat. Proper food and care hasten the shedding of the hair; opposite conditions tend to postpone it. Hair generally corresponds in color to the pigment in the skin which it covers. As the animal grows old, there is a tendency for the hair to turn gray, especially about the head. The color of the hair which comes in over a wound is often white. The foal is generally quite different in color to what it will be at maturity. On account of their color, gray horses seem better able to withstand heat than black.

Horsemen like to see a glossy coat and fine, short hair, as these are indications of good condition, which means ability to utilize feed to the best advantage. Coarse hair denotes coarse skin. Horses running at pasture show a long, lusterless, rough coat from lack of grooming. The long hair on the legs of draft horses is termed "the feather." When "silky" it is a sign of good quality in both the skin and bone.

The *chestnuts* and *ergots* are the callus-like, horny growths seen on horses' legs. The former are usually regarded as vestiges of the first digit. They are of variable form and size and occur on the inner surface of the forearm, and on the lower part of the inner face of the hock. The ergot is a small mass of horn which is situated in the tuft of hair at the fetlock. It is the vestige of the second and fourth digits and hence is absent in cases in which these digits are developed.

Horn is skin that has undergone a modification. It consists of tubes of minute size held together by a cementing substance.

THE FOOT

The *foot* of the horse is a most important structure (Fig. 57). The utility of the animal may be largely measured by the fitness

of the foot for service.   All the parts of the foot to be described represent counterparts of the skin.
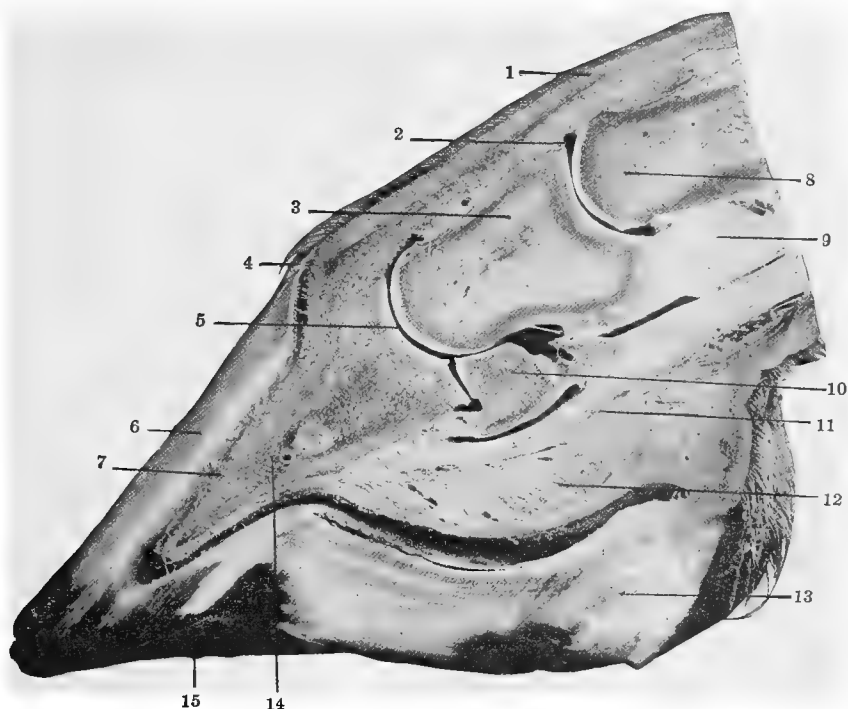
1. Skin. 2. Cavity of pastern joint. 3. Second phalanx. 4. Perioplic band. 5. Cavity of coffin joint. 6. Wall. 7. Laminæ. 8. First phalanx. 9. Superficial sesamoidean ligament. 10. Navicular bone. 11. Deep flexor tendon. 12. Plantar cushion. 13. Frog. 14. Third phalanx. 15. Sole.

Fig. 57.—Longitudinal section of foot of horse. The hoof separated from the sensitive parts before photograph was taken, which accounts for the artificial space between them.

The different structures comprising the foot are: (1) *organs which give the foot elasticity;* (2) *sensitive or nutritive organs of the foot;* (3) *the protective organ of the foot.*

The **plantar cushion** is the chief elastic organ. It is a buffer of fibro-elastic tissue, situated between the horny frog below, the deep flexor tendon above, and the lateral cartilages on each side. It assists the horny frog in lessening jar and protecting the foot.

The **lateral cartilages** comprise the other two elastic organs. They were described with the bones of the foot.

The **pododerm** is the collective term used for the sensitive organs of the foot. It covers the foot in a manner similar to that in which the skin envelops other parts of the body, but is relatively thicker and more resistant. Instead of producing the epidermis and hair, it gives rise to and furnishes nutrition for the hoof. When exposed it is found to be the red, sensitive tissue, commonly called the "quick." For convenience the pododerm is divided into the perioplic band, the coronary band, the sensitive laminæ, the sensitive sole, and the sensitive frog. Each of these parts nourishes a corresponding part of the hoof.

The **perioplic band** is a very narrow ring of flesh running around the hoof-head just above the coronary band. From the fine villi on the surface of this band the periople, or hoof varnish, is secreted. This substance is thin, hard, and brittle when dry, its function being to hold moisture and keep the hoof soft and elastic.

The **coronary band** is a bolster-like structure, about $\frac{4}{5}$ inch wide, which extends entirely around the foot from the bulb of one heel to that of the other. It lies in a groove at the upper border of the hoof. From it the horny wall is nourished.

The **sensitive laminæ** consist of a large number of fleshy leaves, longer at the toe than at the heel, that correspond with laminæ of the wall, which they nourish.

The **sensitive sole** covers all the lower surface of the foot except the plantar cushion. It presents thousands of villi which nourish the horny sole.

The **sensitive frog** covers the lower surface of the plantar cushion and nourishes the horny frog.

The **hoof** is the protective organ of the foot. It is the box, or case of horn, enclosing the sensitive structures. Numerous

minute tubular fibers resembling hairs firmly cemented together make up the hoof. From the standpoint of horseshoeing it is next in importance to the shoe; from that of utility it is paramount, as it is a reliable guide to the condition of the important parts which it covers. The hoof is divided into the wall, the sole, and the frog (Figs. 58, 59).

The **wall** is all that portion which is seen when the foot rests upon the ground. It gives the foot its form. This horn is very hard and solid and affords adequate protection to the sensi-
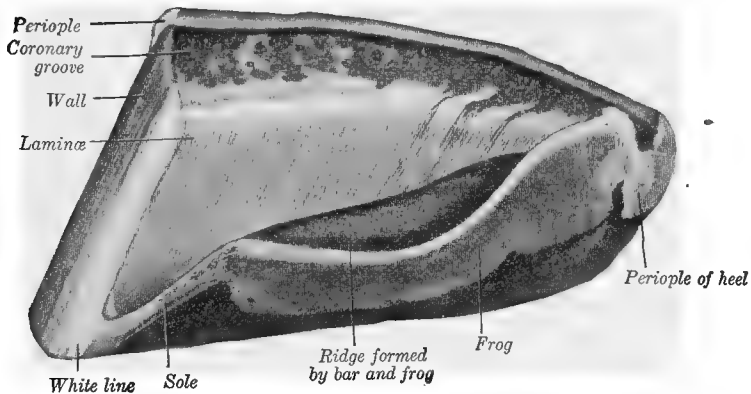
FIG. 58.—Half of hoof of horse, internal surface.   (Sisson, Anatomy of Domestic Animals.)

tive structures beneath it. The wall is arbitrarily divided into toe, quarters, and heels. The toe is the highest part; from this point backward the wall gradually decreases in height, passes around the bulbs of the heels, and turns forward and inward to form the *bars*, which are finally lost in the edge of the sole near the apex of the frog. It thus forms at each heel an angle known as the *buttress*. Each buttress encloses a branch of the horny sole. The inner surface of the wall presents about six hundred horny leaves or laminæ which dovetail with the sensitive laminæ. A firm union is thus made, so that it is very difficult to separate the two. The upper edge of the wall is thin, flexible, and grooved for lodgment of the coronary band. The lower edge is called the "bearing surface," and is the part to which the shoe is fitted. At the toe the wall is thickest; as the quarters are approached it

gets considerably thinner. It requires about twelve months for the wall to grow from the coronet to the ground at the toe, six to eight months at the quarters, and three to five months at the heels.

The **sole** is that horn nurtured by the sensitive tissue covering the sole surface of the coffin bone. It is divided into a body and

FIG. 59.—Right fore hoof, ground surface: 1, Wall at toe; 2, laminæ of wall; 3, angle of wall; 4, bar; 5, sole; 5′, angle of sole; 6, white line (junction of wall and sole); 7, point of frog; 8, median cleft of frog; 9, 9, lateral clefts of frog; 10, 10, bulbs of hoof at the heels. (Sisson, Anatomy of Domestic Animals.)

two branches and is crescent shaped. The sole should be distinctly vaulted. The horn of the sole is friable, brittle, and flaky. Flakes of dead horn gradually loosen and fall off. They should never be pared away with the knife. The outer border of the sole is beveled to correspond to the slope of the wall. It does not come directly in contact with the wall, but is separated by the *white line* of soft horn. This line is of great importance to

horseshoers, as it indicates the thickness of the wall.   The inner border of the sole is a·V-shaped notch which joins the bars except at its narrow part where the frog articulates.

The **frog** is an exact mold of the plantar cushion which it protects.   It is a wedge-shaped mass, filling up the angle between the bars and the sole, and extending considerably below these on the ground surface of the foot.   Thus the frog receives the greatest amount of concussion, but it is seldom injured, for its horn is of very elastic consistency.   The ground surface presents a well-marked *median cleft*, which corresponds to an elevation on the superior surface known as the "frog stay" and which aids to bind the frog to the overlying parts.

The **physiologic movements of the hoof** are due to the fact that the foot is never at rest.   The constant shifting of the weight, even when standing, changes the shape of the hoof.   Adams has grouped these changes of form into (1) An expansion or widening of the whole back half of the foot from the coronet to the lower edge of the quarters.   This varies between $\frac{1}{15}$ and $\frac{1}{12}$ inch.   (2) A narrowing of the front half of the foot, measured at the coronet. (3) A sinking of the heels and a flattening of the wings of the sole. These changes are more marked in the half of the foot that bears the greater weight.   In order to keep the foot healthful these movements must be maintained with regularity.   When the horse is allowed to stand in the stable for days without exercise the results are bound to show in the feet as pathologic changes.

Variations in the activity of the growth of the hoof are shown by more or less distinct ridges on the wall.   These ridges run parallel with the coronary border.   The larger ones are thrown out as a result of decided physiologic changes in the animal's mechanism, such as foaling and a complete change in the character of the feed or environment.   The rings on the horns of cattle are accounted for in the same way as the ridges on the wall of horses' hoofs.

COMMON DISEASES OF ANIMALS

DISEASE IN GENERAL

DEFINITION AND CLASSIFICATION OF DISEASE

Disease includes all those variations from the normal which impair more or less the adaptability of the animal to its surroundings. It is usually accompanied by a feeling of discomfort or loss of ease. Disease modifies existing body structures, but does not add new parts or functional capacities which the normal body does not possess. The usual capacity for work of organs affected with disease may be either diminished or exalted, but no new functions, forms of energy, or other capacities are developed.

Synonyms of the term disease in common use are malady, affection, disorder, sickness, indisposition, ailment, and complaint. The word abnormality is applied particularly to a structural modification like a bone spavin. A congenital structural fault, similar to that of the teeth, shown in Fig. 78, is termed a malformation or defect. An acquired structural fault such as a cocked ankle, shown in Fig. 66, is termed a deformity.

Pathology is that branch of medical science which has to deal with all phases of disease except the treatment. It consists of a study of the modifications in functions and changes in structure caused by disease. A clear understanding of pathology is impossible without a thorough knowledge of the normal structure and functions of the body and the chemical and physical changes that are constantly going on in it. The layman without this complete information may recognize and correctly name such common and outstanding morbid conditions as wounds, fractures of bones, abscesses, galls, etc. He may even learn to treat them properly through observation and instruction. However, he is

185

not able scientifically to interpret the complex picture presented by disease, or to understand the why and wherefore of the process from inception to recovery, for this calls for the training and experience of a professionally educated man.

It is not the intention of the author to discourage the layman by these remarks, but to show him how absurd it is to guess at changes due to disease that even the most thorough investigation has failed to make clear.

Classification of disease on a satisfactory basis has been possible only within the last thirty years, or since the study of bacteriology has revealed the causes of many heretofore obscure diseases. According to cause, diseases are generally recognized as belonging to either one or the other of the following classes: (1) **Non-infectious disease**—one which is caused by something other than living germs; for example, the disease known ,as heaves, in which structural changes are the cause of the disorder. (2) **Infectious disease**—one which is produced as a result of the successful invasion of the body by living germs; for example, tuberculosis, which is caused by the pathogenic microörganism known as the tubercle bacillus. These are commonly known as germ diseases.

Another classification is based upon the nature of the disease from the standpoint of transmission and control as follows: (1) **Non-communicable disease**—one which is not transmissible by direct contact from one animal to another, like colic. (2) **Communicable disease**—one that can be passed on to other animals by direct contact. It is evident that all communicable diseases must be infectious, but that all infectious diseases need not be contagious.

In many treatises diseases are classified, on an anatomic basis, as respiratory, nervous, urogenital, etc., in a manner similar to that followed in classifying the different systems of body organs. A simple grouping of diseases according to their manner of occurrence follows: (1) **Sporadic disease**—one which occurs in isolated cases or at rare intervals; for example, glanders. (2) **Epizoötic disease**—one which occurs in many animals or over a large area at the same time, like influenza. (3) **Enzoötic disease**—one which exists among small numbers of animals or within a restricted area, like heaves.

It is customary to refer to diseases according to their course and

duration, as: (1) **Acute disease**—one which runs a rapid course of a few days, and comes to termination within a time that experience has shown to be fairly constant for that disease, like azoturia. (2) **Subacute disease**—one which runs a slower course than an acute disease, and lasts for two or three weeks, like glanders in the mule. (3) **Chronic disease**—one which runs a prolonged course of from four weeks to an indefinite period of months, or years, or decades, like tuberculosis. In chronic diseases there is no regularity of events in the symptoms which follow. We cannot say when the disease began or when it will end. Affected animals may never be decidedly sick, but gradually lose flesh and vigor until they die or become so worthless that they are killed.

THE CAUSES OF DISEASE

Etiology is the division of pathology that relates to the causes of disease. It embraces the study of a great variety of external and internal influences that operate to produce disease. Most diseases are caused by external influences, even those that apparently originate within the body. For example, faulty body conformation, a hereditary defect, would seem to be of internal origin, but it must have had its external cause in a previous generation as the result of some external influence.

Disease is produced by predisposing and determining causes. Either one of these may be as extensive in exerting damage as the other. Both include agents that operate from the outside as well as from the inside of the body.

I. **Predisposing Causes.**—These are also spoken of as indirect, remote, distant, or accessory causes because they produce a disposition toward disease. They simply prepare the way for easier attack by the determining causes, to be described later, by sensitizing the body. Often they are responsible for the appearance of disease in the animals on one farm, while those on a neighboring farm remain healthy.

The following agents are the main predisposing causes of disease. Without a thorough understanding of them it is certain that one cannot intelligently check or prevent recurrences of disease:

(1) *Climate* influences the health of animals and causes disease indirectly by being too warm or too cold. A warm, moist climate

is most favorable to the development of infectious diseases and those caused by animal parasites, as it favors the development of these organisms. When the temperature of the atmosphere rises above that of the body there is greater possibility of heat and sun-stroke. A cold, dry climate is most conducive to the preservation of health, as it is antagonistic to the growth of germ life. Climate changes involving sudden transition from a cool to a tropical climate or vice versa render the system liable to various disorders, and are also capable of producing immediate disturbances in the respiratory organs like a cold, congestion of the lungs, or pneumonia. Protracted exposure in a cold climate reduces the resistance and predisposes to catarrhal affections of the respiratory organs. These diseases are rare in the tropics. The most notable effect of climate is seen in the difference in the hairy covering which animals grow under different climatic conditions.

(2) *Air* may carry infection from place to place. Epizoötics may be spread by high winds, or infection carriers, like winged insects, carried by winds over large areas. Contaminated air, particularly when combined with poor ventilation and containing suspended matter such as dust, bacteria, and gaseous impurities is responsible for the rapid dissemination of disease in large stables. When such air is inhaled it disturbs the functions and lowers the vitality of the body. The smelters at copper mines may emit such large amounts of poisonous gases which are carried away in the air, that the verdure in their vicinity is destroyed and animals are thus deprived of food or poisoned by eating contaminated forage.

(3) *Soil* is important insofar as it is wet or dry. When animals are kept for long periods on marshy soil their general powers of resistance seem to be lowered. At one time it was believed that the mist arising from marshy places gave rise to certain kinds of fever. Now it is known that while these fevers are more prevalent in such places, they are due to particular forms of germ life that thrive in a wet environment, rather than to the soil itself, *e.g.*, yellow fever, malarial fever.

(4) *Food* is usually considered to be a predisposing cause of disease, but when the animal is deprived of it until starvation threatens, it becomes a direct cause. When fed to excess it leads to distension of the stomach and may even rupture the walls of

the organ.   Too much dry, highly nutritious food will clog up the
digestive canal causing constipation and torpidity of the liver and
other organs.   Overfeeding combined with lack of exercise may
not only affect the processes of digestion and absorption, but also
bring about a condition of plethora by surcharging the blood with
nutrients that the body is incapable of taking care of.   In the
horse in such cases an attack of azoturia occurs when the animal
is put to work; in the cow that is a heavy milker the udder becomes
congested; in sheep a peculiar form of apoplexy that is usually
fatal occurs.   Insufficient food causes lack of nourishment, with
loss of strength, weight, and resistive power to disease.   During
the growing period if not enough food is provided the young
animal's growth is retarded, often to such an extent that even
in later months on full feed it is prevented from fully developing.
A ration that is too laxative will produce flaccidity of the whole
system and a general lack of vigor.   When the ration is spoiled,
or of a nature that ferments easily, large amounts of gases form
and if the natural outlets are closed or unable to take care of the
excess, bloating and other digestive disorders occur.   Moldy
fodder has caused abortion in mares, and forage poisoning in
horses and cattle.   Skimmed milk from tubercular cows may
contain the germs of tuberculosis and has been known to be the
medium through which hogs have acquired the disease.

(5) *Water* at the wrong time or at too long intervals may be
harmful and cause digestive disturbances.   Too little water gives
insufficient fluidity to the food mass and leads to constipation.
Animals deprived of water for a long time lose their appetite for
solid food, and often develop a persistent diarrhea when water is
again provided.   Water from a contaminated source has been
found to be the origin of some outbreaks of disease, particularly
those of a parasitic nature.

(6) *Work* plays a part in acquiring disease.   In man the name
occupational diseases is given to those that occur in persons
engaged in a particular kind of work.   In animals such a division
is unnecessary.   When young horses are worked too hard before
their bones are matured they may sooner or later develop unsound-
nesses.   Draft horses used for years on the pavements of city
streets acquire a disposition to certain forms of lameness.   When
animals are put to work immediately after a full feed an attack
of colic is apt to result.   Excessive work loads the body with

waste products faster than the excretory organs can dispose of them. This results in those conditions known as fatigue and exhaustion from which recovery is slow or incomplete and which predispose to disease.

(7) *Lack of exercise* and confinement to close, ill-ventilated stables are more detrimental than allowing free range with no protection. Interference with the blood supply and nourishment in all parts of the body occurs when animals are deprived of daily exercise. The results are seen as swollen legs, constipation and indigestion.

(8) *Age* has a marked influence in the development and fostering of special forms of disease. The foal and calf suffer from diseases that the adult horse and cow are immune to, because the defensive properties of their bodies are not fully developed. In advanced age there is a predisposition to rheumatic affections and joint diseases.

(9) *Sex influence* is confined to the diseases of the generative organs and to them only insofar as they differ in structure and function. For example, the uterus and udder of cows are particularly suited to the growth and development of the germs that cause contagious abortion, but these organisms seldom infect the bull's reproductive organs because no suitable place for the growth of the abortion bacilli is found in them. Males are especially liable to urethral calculi. Otherwise males and females are equally liable to all affections of their species.

(10) *Other diseases*, as well as a previous attack of the same disease, may influence the development of subsequent diseases. This is seen in pneumonia which sometimes weakens the resistive powers of the animal and renders it more liable to successful attack by tuberculosis and other infections. One attack of founder makes the horse susceptible to a second attack. Fortunately, if an animal has passed through an acute infectious disease it is usually protected from further attack by the same disease, for a time at least.

(11) *Hereditary predispositions* to disease are derived from one or both parents. For this reason breeding animals that are inbred, immature, too closely related, or weakened from any cause will predispose the offspring to disease. Just how these factors affect the animal are matters that are fully taken up in courses in

genetics. It should be understood that predisposition to is vastly different from inheritance of disease. The latter condition is seen in certain human families which for generations have been susceptible to such diseases as insanity, goiter, asthma, and deafness. Commonly a whole generation is skipped and the disease does not appear for years. In other cases, the tendency to disease is transmitted through the female side of the family to the male as in color blindness. While heredity does not appear to play so important a part in the development of diseases of domestic animals as of man, it is a factor in diseases of the bones and joints of horses.

Specific diseases, external mutilations, and all other acquired characteristics cannot be transmitted to the offspring, as they are not present in the germ cells. For example, it is common to crop the ears of dogs, yet a breed of short-eared dogs is unknown. Occasionally the newly born animal is found to be infected with a specific disease, but in this case the disease was transmitted to the fetus *in utero* and is not heredity in the biological meaning of the term. Under such circumstances the newly born animal acquires the same disease that the maternal parent is affected with, *e.g.*, tuberculosis of calf when cow has uterine tuberculosis.

(12) *Auto-intoxication* is a self-poisoning due to an accumulation of poisonous substances in the body as a result of defective elimination or faulty cell metabolism, such as irregularities in digestion. When the digestive system fails to dispose of the by-products promptly, they are absorbed and act as poisons to other organs. The liver and kidneys, which normally throw off certain waste products, are placed under too great strain. This results in an inflammation of these organs and interference with their functions. In the horse, azoturia is a notable example of auto-intoxication due to an excess of nutrients in the blood. Fecal toxemia due to constipation is a form of auto-intoxication, common in man, that is first noticed by headache and dullness. Later all the excretory channels are overtaxed and the entire body becomes poisoned and deadened.

II. **Determining Causes.**—These causes operate directly to produce disease and are accordingly known as direct, immediate, physical, or exciting causes. They act more effectively if some predisposing cause has first been operative. Sooner or later all

determining causes produce visible changes in the tissues that are termed *lesions*. Generally speaking lesions are the result of disturbed nutrition, or mechanical, thermic, electrical, or chemical injury. While it is doubtful if predisposing causes in moderate action are capable of producing a distinct lesion of sufficient importance to be termed disease, it is certain that actual disease will be produced by any of the following determining causes:

(1) *Traumatisms* comprise all mechanical causes that damage the body structures, or in any way disturb the functions of a part of the body. Under this head are classed sprains and strains; cuts, tears, and bruises; excessive pressure and rubbing from an improperly fitted collar or saddle, which produce injury first to the subcutaneous tissues and then to the surface of the skin (galls); electric shock or burns either from contact with a charged object or from lightning. A burn of any kind is a traumatism; likewise a frostbite. When well-marked, either of these injuries leads to death of the affected part. Light is yet another physical cause of disease for undue exposure to light may result in affections of the skin or eyes. A more complete discussion of traumatic injuries and their treatment will be found in the chapter on Wounds. Mention should be made of surgical operations in this connection, as they are often the exciting cause of serious disease especially when improperly performed and when the surgical-wound is not given needed after-treatment.

(2) *Poisons* are substances that destroy life or impair the functions of one or more of the body organs. They may be separated into three classes, as follows—*animal poisons*, like snake venom, which is highly toxic; *vegetable poisons*, like opium and strychnin; *mineral poisons*, like arsenical salts, caustic soda, and silver nitrate. Some mineral poisons exert their destructive influence by causing a coagulation of the tissue-juices; others, by causing a liquefaction of the tissue-cells. Many animals seem to be endowed with an instinct which teaches them to avoid most poisons. Some poisons, such as snake venom, are entirely harmless when taken into the body by way of the mouth, but are deadly if introduced through the skin. Other poisons are most active after gaining access to the blood or some other tissue. Still other poisons are harmless until their composition has been changed in the animal body, thus calomel is probably converted

into corrosive sublimate by the action of the hydrochloric acid of the gastric juice.

(3) *Animal parasites*, such as lice, ticks, mites, and worms, through infestation of the body, may cause disease in various ways, as will be shown in a later chapter. They are usually not given so much consideration by livestock men as the damage caused by them deserves.

(4) *Vegetable parasites* that are known to produce disease include certain fungi, molds, rusts, and smuts. They grow most luxuriantly on grain and forage which have been improperly harvested. During wet seasons when conditions are most favorable for their growth this class of parasites thrives best. The animal diseases most commonly produced by vegetable parasites are lump jaw of cattle and forage poisoning which affects both cattle and horses.

(5) *Bacterial parasites* include all other microscopic organisms that are capable of causing infectious diseases. Collectively they are known as pathogenic microörganism or disease-producing germs. They are of various types and habits and cause damage by liberating enzymes, producing toxins, transforming the chemical reactions of the surrounding media, or by giving off offensive substances (aggressins) that inhibit the defensive reactions of their host. Examples of bacterial toxins that are very poisonous are tetanus toxin, the product of the tetanus bacilli, and diphtheria toxin, which is produced by the germs that cause diphtheria.

(6) *Viruses* are living agents capable of causing disease and yet are so extremely minute that even the highest power microscope is incapable of revealing them. None has yet been successfully propagated outside the animal body.

THE PROPAGATION AND TRANSMISSION OF DISEASE

Infection is the term used to denote all the changes that result from the entrance, growth, and damage of bacterial parasites, *i.e.*, infectious organisms in the body. The phenomena of infection are to be considered as reactions that result from the conflict between the infecting germs and the body defences. It should be clearly understood that only a living thing can infect. Moreover, it must have sufficient vitality to multiply in the

13

animal body.   Simply finding these bacteria on the surface or in the tissues of the body does not constitute infection.

In order to produce infection, the pathogenic organisms themselves, or their toxic products, must penetrate into the tissues of the body and feed on its proteins.   Under natural conditions few pathogenic organisms grow and multiply outside the body, although they may exist for some time.   Any object on which they may be brought into the body is said to be *infective*.   The body into which they are brought is said to be *infected*.   The organisms through which the infection is brought are said to be *infectious*.   This term is also applied to that class of diseases caused by these organisms.

The pathogenic properties of an infectious organism may be summed up in the word *virulence*.   By this is meant its ability to produce disease.   There is as much variation in the capability of growth and toxin production of a given organism as there is in those characteristic in different animals.   The virulence may be intensified or weakened depending upon the resistance offered by the infected animal.   For example, foot-and-mouth disease in some epizoötics runs an unusually severe course and has a high mortality, while in most outbreaks it is not a fatal disease, recovery taking place in the course of two weeks.

Although it is desirable to know the exact meaning of these terms, the point of practical importance is to understand how diseases are transmitted rather than to quibble about the terms to be used.

The entrance of infectious organisms in the body is usually by one of the following paths: The broken skin (cut or wound); the digestive tract (food or drink); the respiratory tract (breathing in germs); the genital tract (sexual intercourse).   In the new-born animal the raw navel forms an important place for both the entrance and the propagation of bacterial organisms. Most infectious agents are incapable of producing infection unless they gain entrance by a particular path.   For example, the tetanus bacillus is harmless when taken into the stomach even in large numbers, while a very few will produce tetanus when introduced under the skin.

The dissemination of infectious organisms in the body varies with the kind, number, and virulence of the bacteria.   Some bacteria remain at or near the site of infection (tetanus); others

spread through the tissues by direct growth (actinomycosis); some are carried by the body fluids to distant parts (strangles); still others may multiply in the blood and locate in various organs where they set up infections by forming local lesions (tuberculosis).

The multiplication of infectious organisms is more rapid after a prolonged disturbance of some kind. For example, if the kidneys have not been performing their work properly, the heart and liver both show the effects of the retention of the harmful products of metabolism by being reduced in efficiency. When these important organs are not working efficiently, any infectious organism in the body would multiply very rapidly.

The elimination of infectious organisms from the body is with the various se- and excretions. For example, the milk is infectious in tuberculosis of the udder; the saliva in foot-and-mouth disease; the urine in cases of hog cholera; the feces in Johne's disease; the nasal discharge in glanders and strangles; the vaginal discharge in contagious abortion; the discharge from wounds in anthrax; the blood in Texas fever and other parasitic blood infections. This list shows how essential it is properly to handle animals that are suffering from infectious diseases to prevent others from becoming infected.

The transmission of infectious organisms can be understood, now that we have considered the ways by which disease-producing germs gain entrance to the body and the avenues by which they leave. The vehicles that usually carry infectious germs from animal to animal or place to place are the air, water, food, and animal parasites. Transmission by direct contact with infected se- and excretions, by rubbing, licking, and biting, and through common feed mangers and drinking places are far more frequent methods of spreading disease than is usually realized.

RESISTANCE TO DISEASE

Resistance to disease is possessed by all animals in some degree. It is more marked in some individuals than others, depending upon age, sex, and breed. The study of disease resistance in animals is one of the most important and interesting subjects that the student of live stock husbandry can pursue. Only a few scientific facts were known about it until the development of experimental research a few decades ago. Even now

there are many things that are not satisfactorily explained or well understood.

Health is that ideal state of the body in which all organs are working in harmony and in which the body is best able to resist attack by disease. It can be maintained permanently only when a perfect balance exists between feed and work. The body, however, has a wonderful adaptive capacity so that it is able to maintain its normal structure and functions in spite of adverse conditions.

The body possesses two classes of defensive mechanisms against disease. One class operates externally, the other internally.

I. **The External Defenses.**—Under this heading are classified the intact skin and the intact mucous membranes. Both are composed of epithelial cells which are capable of excluding most microörganisms and of serving as efficient defenses against all invaders from those surfaces of the body that come in contact with the air.

(1) *The intact skin*, as has been learned, serves mechanically to protect the outer surfaces of the body. When normal it is impervious and highly resistant even to poisons and chemicals. On those parts of the body most exposed to injury it is very thick and tough. Its power of rapid replacement when injured or destroyed renders it well adapted for an external defensive mechanism.

(2) *The intact mucous membranes* are extensions of the skin and serve to prevent invaders of a bacterial nature from entering the tissues which they cover. These membranes are normally always moist and velvet-like from mucus, the secretion which bathes their surfaces and keeps them from erosion when they rub together, as often occurs on account of their situations. The mucus hinders the penetration of bacteria and washes them away. In the chapter on respiration an account of the protection afforded by the ciliated cells lining the respiratory passages will be found. Other secretory products that protect are those from the liver and the salivary, the gastric, the lacrimal, and the serous glands. Of especial note are bile and the acid gastric juice, both of which possess marked antiseptic and bactericidal properties.

II. **The Internal Defenses.**—The agencies that afford internal protection to the body against disease are all concerned with

that condition generally termed immunity. They consist of the following:

(1) *The Antibodies in the Blood-plasma and Tissue-fluid.*—These substances are similar in character to enzymes and appear to act in a chemical manner. They are stimulated to production through the introduction of foreign substances. They prevent bacteria from multiplying and neutralize the poisons produced by them. The majority of infections are brought under control by the action of antibodies before they have done any harm and while the number of infecting organisms is small. On the other hand, if the invasion of bacteria is great, the antibodies are not capable of overcoming them, and disease results either from the mechanical interference produced by the organisms, or from a poisoning of the body by the noxious bacterial toxins which circulate with the blood to all parts of the body. Certain organs are more susceptible to the action of these poisons than others and give way to them more quickly. This is well illustrated in cases of tetanus, where the organs of the nervous system are the first to show the effects of the toxin produced by the tetanus bacilli. Among the most useful antibodies are *antitoxins*, which neutralize the harmful effect of bacterial toxins; *agglutinins*, which cause bacteria to clump or agglutinate and lose their motility; *precipitins*, which precipitate certain organisms under favorable conditions.

The blood-plasma circulates in the blood-vessels. The tissue-fluid, on the other hand, circulates about and bathes the cells of the body. All substances that reach the individual cells are carried by this fluid. Besides food materials and antibodies, it conveys large numbers of leukocytes.

(2) *The Leukocytes or White Blood Corpuscles.*—These cells are capable of passing through intact walls of the blood-vessels and of migrating into the tissues. They congregate at the seat of infection and destroy by an eating process the bacteria that are attempting to invade the tissues. As active agents in aiding the body in the fight against foreign invaders they are very important. Someone has truthfully called them the mobile members of the body's defensive army.

(3) *The Red Blood Corpuscles.*—These cells are capable of oxidizing certain injurious substances when they come in contact with them. The process of oxidation is simply the liberation

of sufficient oxygen to destroy the particular invader. The red blood cells act as carriers of the oxygen from the lungs. So great is the oxidizing action of the blood that such virulent pathogenic germs as the organisms which cause blackleg, when inoculated directly into the blood stream, fail to produce disease, yet they will cause death promptly if inoculated subcutaneously.

The three agencies mentioned above are all concerned with making conditions unfavorable for invaders. When the temperature of the body is elevated it may be regarded as an indication that they are all active and the battle is progressing favorably. The absence of fever, on the other hand, in cases of severe infection, may be an indication that the cells are overwhelmed by bacteria and toxins.

Long ago it was recognized by veterinarians that one attack of certain diseases of animals generally prevented a recurrence. It was also known that these diseases could be transferred only to certain other animals. For centuries the reasons for these natural phenomena were obscure and merely matters of speculation. The beginning of our knowledge concerning the factors responsible for these phenomena dates from 1796, when the English physician Jenner had his attention drawn to it by a woman patient, who told him that she could not take smallpox because she had had cowpox. But it was not until the germ theory of disease became an established fact and the development of experimental research that the full significance and importance of immunity as a means of controlling infectious diseases was realized.

Immunity is the general term used to express all of the factors concerned with the resistance of the body to disease. In a broad sense it may be thought of as that condition in which an animal is protected against certain diseases that others readily contract. The animal may be born possessing it, in which case it is known as natural immunity; or the animal may develop it after birth, when it is termed acquired immunity. So far as is known, immunity is possible only against those diseases that are caused by microörganisms or viruses.

Natural immunity is inherited by the animal from its parents and transmitted to its offspring. It may be an attribute of the species, the breed, or the individual. Hog cholera, a typical infectious disease, will serve to illustrate these three forms of

natural immunity. While hog cholera is usually fatal to swine, horses possess a natural immunity common to the *species* against this disease. An instance where a species possesses a general immunity, but where individuals are occasionally attacked, is seen in tuberculosis of the dog and cat. These animals are usually immune to tuberculosis, but now and then one is found affected with it. *Breed immunity* against hog cholera is claimed by some unscrupulous breeders to be possessed by mule-foot hogs. Experiments conducted to prove this claim have resulted in the contraction of the disease by animals of this breed, so the claim is completely disproved. That breed immunity does exist is shown by the fact that Algerian sheep are naturally immune to anthrax, yet all other breeds of sheep are highly susceptible to it. An example of *individual immunity* is often seen in outbreaks of hog cholera, in which a few hogs pass through the infection without getting sick, although hundreds die. The individuals in these cases must be above the average of the species in immunity. It seems reasonable to attribute their protection to such factors as "strong constitution" or "good condition" rather than to specific bactericidal and other properties of their blood-serum.

Acquired immunity is the result of some influence acting after birth. It occurs after recovery from a natural attack of disease or from injecting the animal with living, weakened, or killed germs of disease or their products. When this is done, a reaction similar to an actual attack of the disease takes place. Prepared for use in this manner, the germs are known as vaccines or bacterins and the process of administration is called vaccination. It may be thought of as a reinforcement of the body to guard against disease. The result is *active immunity* which varies greatly in length in different animals, but may be permanent and last for life. The development of active immunity is slow, more or less dangerous, and always attended with some discomfort. Several doses of a vaccine or a bacterin properly graduated often give better results than a single dose in attempts to confer immunity.

As has been stated, after an animal has recovered from many infectious diseases, its blood contains substances that protect it from future attacks. What is even more remarkable is that the fluid part or serum of the blood from a recovered animal, when

properly extracted and prepared, will prevent the same diseases from developing in other animals that are liable to them. When such serum is injected into another animal, a *passive* or *temporary immunity* is produced quite rapidly with no danger and little discomfort. The passively immunized animal is simply the recipient of the protective substances or antibodies formed in the body of other animals and transferred to it. An example of this form of immunity is seen in hogs after they have been given the serum treatment to protect them from hog cholera.

It is a matter of common knowledge that very young animals show a definite resistance to diseases that they later get. This is explained by the fact that the mother's milk contains specific protective principles. The immunity, being but passive, gradually disappears after weaning and then the animals become readily infectible. Not uncommonly disease germs, after lying dormant for a long time, suddenly take on new life when the disease is said to "light up." This is due largely to reduced resistance of the animal. In other instances, after a variable course, diseases "die out," due to increased resistance on the part of the infected animal.

Susceptibility is the opposite of immunity. It is shown as sensitiveness or predisposition to disease. Like immunity, it is inherited, at least when particular to a species. The resistance of the animal is lowered, the normal equilibrium is disturbed, and virulent organisms with the body defenses off guard take advantage of the opportunity rapidly to increase in number and to produce disease. It is not uncommon to find certain animals in a herd highly susceptible or predisposed to a specific disease, while the rest of the herd shows great resistance. Experience goes to show that individual susceptibility is often due to a "weak constitution," "poor condition," temporary physical depression, fatigue, exposure to cold, poor hygiene, or poisonous gases. Many of the terrible epizoötics or "animal plagues" of ancient times were probably caused by the introduction of some new germ against which the animals had no natural immunity and toward which they were particularly susceptible.

Constitution is an important factor in determining the resistive influences possessed by the body against disease. An animal is said to have a "strong constitution" when his resistive powers are highly developed and he is healthy and vigorous; and a "weak

constitution" when he is susceptible to the influence of his surroundings. An individual may have much resistance against many types of disease influences and yet be weakly constituted in some way. The strength of general constitution is measured by the strength of the least resistive ability, like the strength of a chain is that of its weakest link. Constitution is indicated by a general healthy appearance and perfect respiration, digestion, and circulation.

Condition is the term used to denote the degree of bodily health. When the animal is enjoying perfect health it is most resistant to disease and is said to be in "good condition," that is, at its highest point of efficiency for the performance of work. Work in this connection signifies either actual labor, or the production of milk, meat, or wool. Condition in working animals is denoted by hard, firm muscles, a clear eye, and quick perception; in meat-producing animals by rotundity and fullness of development of the body; in milk-producing animals by fine quality and pliability of the skin. An animal is said to be in the "pink of condition" when all the organs of the body are working in harmony. The expression probably originated from the fact that the visible mucous membranes of healthy animals are always a delicate pink color.

When one or more of the various causes of disease are at work the animal is "out of condition" and incapable of performing work in the most efficient manner. Under these detrimental influences the natural powers of resistance are weakened and the animal is more susceptible to disease.

The previous pages in this chapter have dealt with some of the causes of disease and the natural means of resistance to disease. Their study should show the student why an infection is fatal in one animal, but may produce only a moderate sickness or cause no damage whatever in another. Moreover, they have introduced the subject of infection and immunity, that ever-waging contest between the invading army of bacteria on the one side and the defending army, consisting of the body defenses, on the other side.

THE SYMPTOMS OF DISEASE

Symptoms are the signs of impairment which occur as the result of disease. They vary in intensity depending upon the organ affected and extent of the disturbance. Only when an

organ or group of organs is affected to such an extent as to cause visible impairment, or to interfere with their performance of usual functions, can symptoms be detected.

The following kinds of symptoms of disease are recognized:

(1) **Subjective symptoms** are appreciable by the affected individual alone, for example, pain and impairment of vision.

(2) **Objective symptoms** are discoverable by or visible to the examiner, for example, faults in conformation, defective gait, and impaired respiration.

(3) **General symptoms** are present in nearly all serious cases of illness, but do not indicate any definit : or specific disease; on this account they are not of great value, yet their presence is important for they may show the absence of certain diseases with which the disease under consideration might be confounded. Examples are loss of appetite, sluggishness, skin dry and hot or cold and clammy, trembling of muscles, elevation of temperature, rapid breathing, cough, and constipation or diarrhea.

(4) **Special symptoms** indicate disturbances of a particular nature or organ, and by which the disease may be positively recognized, for example, spasms of the muscles in tetanus, swollen lymph glands in strangles, paralysis in milk fever, and jaundice in liver troubles.

In veterinary practice it is impossible to determine definitely in all cases the exact period at which there is a departure from the normal state and commencement of disease. This is due to the fact that animals do not have the power of speech to convey information to man concerning internal troubles, and because the alterations are so slight that they are not noticed by the examiner.

The duration and time of appearance of the symptoms in an infectious disease depend upon the resistance of the individual and the virulence of the infecting organisms. The formula $D = \dfrac{V}{R}$ is used to represent the variations in the course of an infectious disease. D represents the duration of the disease (acute, subacute, or chronic), V the virulence of the organism, and R the resistance of the body. When the resistive forces of the body are high and the virulence of the organism is low, the duration of the disease is short. On the other hand, if the resistive forces are weak and the invading organisms are strong in either

virulence or number, especially in both, the appearance of the symptoms of the disease is rapid and their intensity great. In a case of this kind a large quantity of toxin has been produced by the organisms and it rapidly alters the physiologic processes of the animal so that visible effects are soon evident.

THE DIAGNOSIS OF DISEASE

Diagnosis is the art of determining the nature and location of disease. It is the first step in the effort to restore health, and is very essential in preventing the spread of communicable diseases. Without a correctly made diagnosis it is impossible to prescribe intelligent treatment. Therefore, the importance of ascertaining what ails the animal before proceeding to doctor it must be apparent.

In order to learn how to diagnose the diseases of animals correctly, one must be familiar with their normal habits, behavior, actions, and the appearance of their skin, mucous membranes, se- and excretions, respirations, etc., so that he will immediately recognize those slight variations from the normal that are the first signs to appear at the onset of disease. Such experience can only be obtained by actually caring for and handling animals.

Inability to determine the subjective feeling of the patient is not such a handicap as may be supposed, because the objective examination is always possible and no notions, false modesty, vanity, or pride on the part of the patient need be considered.

Care must be taken not to confuse those changes which occur in the body as a result of external influences with symptoms of disease. To illustrate, if a horse refuses feed it may be due to colic, excitement, or to poor feed. Therefore, we must consider in making a diagnosis the work, food, care, and exercise, which the animal has had. This precaution applies particularly to changes in the pulse, respirations, and temperature.

The fact that even an experienced veterinary diagnostician frequently finds it necessary to visit a sick animal two or three times before he is able to make an entirely satisfactory diagnosis, is evidence enough that the stockman should not expect to be able to recognize many of the diseases affecting his animals. It further emphasizes the need of expert professional advice to determine just what disease is present, to what extent it has progressed, and what line of treatment should be instituted.

In the majority of cases the diagnosis of any competent veterinarian can be relied upon by the owner. In obscure conditions the attending veterinarian will often ask a fellow practitioner in counsel.

In making a diagnosis it should be understood that nothing is to be taken for granted. All deductions and conclusions must be based on scientific facts that cannot be shaken by prejudice, tradition, or superstition. The examiner should follow a systematic course and use everything at his command that will throw light upon the physical state and functions of the animal's body. He will use his senses of speech and hearing to collect evidence from the attendant, and his senses of touch, sight and hearing to collect evidence from the patient. Moreover, he will bring to his aid specially designed instruments of precision for the various senses, and even a detailed laboratory examination if the above means have not furnished sufficient information to make the diagnosis complete.

After questioning the attendant as to the history of the case, the experienced diagnostician does not at once rush up and put his hands on the animal, but first carefully *inspects* the animal and its surroundings with his eye, to record visible changes in the character of the respirations, the appearance of the se- and excretions, the posture, and the movements. Then he *palpates* with his fingers to determine the shape, size, and consistency of the superficial and deep-lying organs. Finally he *auscultates*, by applying his ear to various parts of the body, to detect unusual sounds produced as a result of disease in the internal organs.

Enough has been said to show that the all-important as well as the most difficult thing about disease is that of finding the real underlying cause. Our powers may often be taxed to the utmost in arriving at a correct diagnosis. In the next few paragraphs is given an outline of the course of procedure to follow in making both a general and special examination.

The general examination consists in a careful study of the following things, all of which will shed light on the actual state of health:

(1) **Attitude and Behavior of the Animal.**—Healthy animals stand or lie quietly, but sick ones assume peculiar attitudes and if suffering severe pain may be restless. For example, in pharyngitis or sore throat the head is poked out; very sick animals hold

the head down and droop the ears; the fore legs are held apart in chest troubles; horses suffering from azoturia or tetanus are often unable to rise; in acute founder the horse stands with the hind legs well under the body and cannot be made to back; in diseases of the nervous system the behavior may be markedly altered and spasms and convulsions, or paralysis and unconsciousness occur.

(2) **Examination of the Skin.**—The skin's condition is an indication of the state of health. When the hair-coat is smooth and glossy and the skin pliable and elastic, the digestive organs are functioning properly, and the animal is in good condition. When the coat loses its luster and the skin becomes dry, scurfy, and "hidebound," it indicates disturbed nutrition and an unhealthy condition of the body. The long, rough, heavy coat that an animal grows when not given warmth and shelter during winter, should not be mistaken for an abnormal condition. It is a provision of nature to afford protection against severe cold and to prevent too rapid radiation of heat from the body. Alopecia, or falling of the hair from over the entire body, may follow recovery from severe diseases. The condition of the skin as to sweat secretion should be carefully noted. Profuse sweating occurs as a result of weakness, pain, and certain diseases of the muscles.

(3) **Examination of the Visible Mucous Membranes.**—The mucous membranes lining the eyelids and those at the natural body openings, reveal the character of the circulating blood. In health they are pink in color and moist in appearance. Paleness indicates a congestion of blood in other parts or a deficiency of the blood in general (anemia). Marked redness or injection is present in all irritated conditions (inflammation). A very dark red color indicates a lack of oxygen in the blood (cyanosis). A yellowish discoloration occurs when the liver is deranged (jaundice). Dryness indicates fever.

(4) **Examination of the Pulse, Respirations, and Temperature.**
An examination of the pulse, respirations, and temperature aids greatly in determining the state of health. None but a trained veterinarian can detect the minor variations from the normal. If the changes are marked, any person with a little practice should be able to recognize them. It should be remembered that they all vary normally within certain limits with the age and exercise which the animal has had.

The *pulse* is the intermittent wave in an artery that is caused by the heart forcing blood into the arterial system. As it is usually impossible to count the number of beats for a full minute, they should be taken for ten seconds at two or three different times, and the average multiplied by six to get the pulse rate per minute. Variations as to frequency, rhythm, and quality may be noted. The pulse is fast in severe disease accompanied with fever, in all painful conditions, in excitement, and following severe hemorrhage. A hard pulse is always associated with a serious disorder.

The frequency of the pulse varies normally with the species, age, size, and temperament of the animal. The younger the animal the more frequent the pulse. An animal of nervous temperament is easily excited by noises, strangers, feeding, and slight exercise and has a pulse rate higher than would be found in an animal of phlegmatic or lymphatic temperament.

The normal pulse of the different adult farm animals follows:

Horse............................... 28 to 40 per minute
Ox.................................. 45 to 50 per minute
Sheep............................... 70 to 80 per minute
Hog................................. 70 to 80 per minute

The horse's pulse is usually taken at the margin of the jaw, where an artery winds around from the inner side. Other arteries that are superficial enough to be easily felt are located at the inside of the elbow and under the tail.

The ox's pulse is taken on the outside of the jaw just above its lower border. Another very convenient place is the soft place immediately above the inner dewclaw.

The sheep's pulse is taken on the inside of the thigh where the femoral artery comes in close proximity to the skin.

The hog's pulse can be felt in the same place as that of the sheep.

Variations in rhythm and quality of the pulse are more difficult to recognize than variations in the number of beats. When well marked they should be considered serious signs and the attending veterinarian asked to interpret their meaning.

The *respirations* may be counted by observing the rise and fall of the flanks, or in winter by watching the steam coming from the nostrils. Rapid respirations due to recent exercise or excitement should not be confused with disease. A pathologic increase in

the number of respirations is spoken of as dyspnea or labored breathing.   Nearly every form of lung or chest trouble is accompanied with accelerated respirations.

The frequency of the respirations varies with the species, within certain limits, as may be seen by the following table:

Horse..............................	8 to 16 per minute
Ox................................	12 to 15 per minute
Sheep.............................	12 to 20 per minute
Hog...............................	10 to 15 per minute

Normally the ratio of the pulse and respirations is about 1 : 4 or 1 : 5.   In disease this ratio is decidedly altered.   Audible sounds are produced during respiration if the passage of air to and from the lungs is mechanically interfered with, as in paralysis of the larynx (roaring), and when tumors form in the nose, throat, or trachea.   Horses with heaves exhibit a double-pumping action of the flanks during expiration.   Cattle suffering from bloat have difficulty in breathing as a result of compression of the lungs by the greatly distended paunch.

The odor of the expired air should be noted in making the general examination and during the progress of the disease.   In that form of pneumonia in which the lungs decay or become gangrenous, the expired air has a putrid and very offensive odor that permeates the atmosphere about the affected animal.

The *temperature* is measured by inserting a clinical thermometer full length in the rectum, where it should be left at least three minutes for accurate registration.   Every person who has the care of stock should provide himself with one of these instruments, as it is a most valuable guide for the early detection of disease.   In the old days the temperature of an animal was determined by simply laying the hand upon the body of the patient.   The ears, nose, and legs are the first parts of the body to show temperature variations.   With the thermometer we have a much more accurate method of determination.   A maximum-registering thermometer is used, and it must be carefully shaken down before insertion.   Fig. 60 is an illustration of a thermometer designed especially for the horse; the arrow points to the average normal temperature.

It is not possible to give an exact figure for the temperatures of the different farm animals under normal conditions as it is

for man, therefore the figures given in the following table are approximate:

Horse	about 100.2°F.
Ox	about 101.5°F.
Sheep	about 103.5°F.
Hog	about 102.6°F.

In order to arrive at a fairly accurate figure, for a given animal, it is often necessary to take two or more readings at an interval of an hour, and compare them with the temperatures of other healthy animals in the herd.

Infectious diseases are always ushered in with a rise in the temperature. By working or even standing in the hot sun, or by confinement in a very warm stable, the temperature of an animal may go up two degrees, in which event it is not an indication of disease. Large drinks of ice-cold water or exposure to a very cold, penetrating wind may cause the temperature to fall below normal. These and similar influences should always be taken into account when making the examination.

A rapid rise in temperature of six or eight degrees with as quick return to normal is a less dangerous signal than a slow rise of three or four degrees that is maintained for some time. For example, in garget or acute inflammation of the cow's udder, the temperature may run up to 107°F. or higher without risk to life, as it soon comes down again; while in certain other infectious diseases the temperature hovers around 103.5°F. for days until death finally ensues.

The special examination includes the three following aids, all of which are necessary to enable one to realize the exact meaning of many symptoms:

(1) **Diagnostic Inoculations.**—These consist in the introduction of certain agents into the bodies of animals for the purpose of recognizing disease or of obtaining an early diagnosis. They are only serviceable in those cases where the examination leads us to suspect some infectious disease. They are injected under or into the

FIG. 60.
Clinical
thermometer.

skin, or instilled into the eye of the patient. If the animal is infected either a local swelling or general fever reaction follows, sometimes both. Examples of these diagnostic agents are tuberculin for diagnosing tuberculosis, mallein for glanders, and johnin for Johne's disease.

(2) **A Postmortem Examination.**—This part of the special examination is conducted for the following reasons: (a) to determine whether death was due to violence or a poison; (b) to account for a sudden death; (c) to study the lesions of disease. In this work training and experience are called for to distinguish between changes due to disease and those caused by physical conditions. To be of most value, the postmortem should be held within a few hours after death, as decomposition changes set in rapidly, especially during warm weather. Fortunately the old-time antagonism against holding postmortems no longer exists.

Before moving a dead animal to a proper place for the postmortem examination, the body should be inspected for external evidences of disease. The natural body openings should be inspected for abnormal discharges which are significant of generalized infections, although bloating, decomposition changes, and similar conditions may be responsible for them. When summing up the results of the examination all external changes of an abnormal nature must be considered.

The chief changes to be looked for in the internal organs are the result of congestion of the blood. This is manifested by the appearance of areas from the size of a pin-point to that of a letter-head and of a red to purple coloration. After death the blood in the vessels often gravitates to the lowest parts of the body and may be mistaken for an antemortem change in those organs in which it has accumulated.

In many infectious diseases the lymph glands are most the valuable guide at the autopsy. They are located in connection with all important organs, and are the first structures to show evidence of trouble because they act as filters of the lymph which has bathed the tissue. Lymph glands serve as active agents in limiting the spread of invading bacteria to other organs.

The carcass should be rolled upon the back and propped up in that position. Then an incision is made through the skin and muscles of the abdominal wall from the sternum to the pelvis

14

to bring the viscera to view.   After careful inspection of the
exposed organs for pathologic changes, the carcass may be inclin d
to one side, and the stomach, intestines, spleen, bladder, and
other soft organs removed for a more detailed examination.
Care should be used to avoid puncturing the hollow organs, for
their contents will escape and may seriously interfere with
further work.

The incision, made when the abdomen was opened, should be
carried forward to the throat.   At this time it will be best to
examine the nasal cavity, pharynx, esophagus, and trachea.
In order to get at the organs in the thoracic cavity it will be
necessary to divide the sternum or breast bone in its length.
Especial note should be made of fluid found in this cavity.   An
excessive quantity indicates pleurisy.   Adhesions of the lungs
to the inner sides of the ribs are found as a result of inflammatory
changes in the lungs.   Healthy lung tissue is soft and spongy.
If pneumonia is present, dark-red, firm areas will be found.

(3) **A Biologic Examination.**—The recognition of the patho-
genic organism, its products, and the effects of these upon the
animal tissues are included in the biologic examination.   It is
often necessary, in order to establish the actual cause of
infectious and parasitic diseases, to examine the secretions, body
fluids, and tissues with the aid of a microscope.   Such an ex-
amination is useful while the animal is sick as an aid to rational
treatment, and very valuable after death in showing what
measures should be followed to protect other animals from a
similar infection.   In doubtful cases an experimental animal is
inoculated with blood or pus from the suspicious subject.
Within the last few years several different laboratory tests of
the blood-serum and milk have been used to point out diseased
animals.   Those of practical value are the complement-fixation,
agglutination, and precipitation tests.

When the general and special examinations have been made,
a conclusion as to what disease actually exists is arrived at by the
processes of comparison and elimination.   The changes that
occur in the various possible diseases are reviewed and con-
trasted with those presented by the subject.   This reveals
similarities to the examiner from which, in most cases, he should
be able to make a definite diagnosis.

After the diagnosis has been established, the *prognosis*, which

is the examiner's opinion as to the probable result of the disease, may be made. The prognosis may be favorable, unfavorable, or uncertain and can be pronounced with accuracy only for an individual case.

THE PREVENTION AND CONTROL OF DISEASE

Prophylaxis is the art of preventing the occurrence and extension of disease. The term is similar in meaning to, but is not synonymous with, hygiene.

Hygiene is the art of conserving and promoting the health. It teaches how to strengthen the animal organism and increase its powers of natural resistance.

Much more attention is now being given to the prevention and control of disease than ever before. This is the result of a better knowledge of disease processes which has been afforded by the valuable contributions to the study of bacteriology and pathology. We have come to realize that it is much more economical to keep our animals free from disease than to wait until they get sick and then spend both time and money to restore them to health.

The difference between a herd or flock kept free from disease and one in which disease is more or less prevalent represents the difference between profit and loss in the business of live stock production. Even if the farmer has plenty of capital he cannot make a success if he neglects to recognize the causes of diseases and fails to use the most up-to-date preventive and remedial measures to control them. On the other hand, if the farmer has limited means and does not take these things into consideration, he must sooner or later meet a heavy loss from sickness and death in his stock. This is certain to result in great financial loss and may even force him out of business entirely.

While preventive measures may be instituted to guard animals against all classes of diseases, they are particularly effective against those caused by microörganisms. In fact all germ diseases can be prevented if steps are taken, before infection occurs, to destroy the specific organism. To succeed in this, it must be understood that the main breeding place of disease-producing germs is in the body and not in manure piles, sewers, marshes, and other filthy places; although dark, sunless buildings do afford conditions favorable to their development. Experiments

have shown that the germs of tuberculosis may remain alive in cow manure for nearly a year and in water for even a longer time. The germs of anthrax are known to retain their vitality in dry soil for fifteen years.

The main factors in keeping an animal healthy are a strong constitution, which is inherited from healthy parents; good condition, which is maintained by adequate food, water, air, light, and shelter; protection from injury and disease. These factors have been referred to in previous pages. In addition, when a serious attempt is made to prevent and control disease, attention must be paid to the following important procedures:

(1) **The Selection of Animals for Breeding.**—If animals used for breeding purposes are defective, their offspring will inherit weakened constitutions. Breeding from immature, inbred, unsound, or very old animals, either dams or sires, is the main cause of inherited weaknesses. It is a mistake to use for breeding purposes animals that show physical weaknesses. The progeny of such animals may be of normal size, but lack vitality and either are born dead, or die during the first few weeks of life. Others lack in development when born and never overcome the handicap. By breeding only from sound, vigorous, mature stock, diseases and weaknesses of this nature can be avoided. Before making a final selection of a pure bred animal for breeding purposes, great care should be taken to determine that it meets these requirements. Besides paying careful attention to the selection of animals, the breeder should avoid unnatural forcing and pampering; should look particularly to size, energy, and massive development in the male and to fine quality and maternal characters in the female. Reference should be made to text-books on animal breeding for further information relative to breeding practices.

(2) **The Increase of the Resistive Powers of the Body.**— This is a means whereby infectious diseases may be prevented. The process of conferring protection against disease by treatment with either an attenuated form or a sublethal quantity of the infectious agent of the disease or its products is spoken of as "active immunization." Immunization is recommended either when other methods of prevention are impracticable, or when it is desirable to strengthen the body against a specific infection. To be of the greatest value it should be employed

before the natural recuperative powers of the body have been exhausted from conflict with the forces of disease.

(3) **The Elimination of Disease Carriers.**—If diseases are to be prevented from spreading, all agents that are capable of carrying germs from place to place must be watched. In this connection may be mentioned dogs, birds, and all animals coming from infected premises, whether they themselves are sick or apparently healthy; insects such as the flies, which lay eggs from which bots and grubs develop, and the Texas fever tick; hay and grain from quarantined areas; stock cars, wagons, pens, and show yards in which animals from infected farms have been confined.

Probably, the water supply is more often a means of spreading diseases of farm animals than any other inanimate object. The public watering trough, the stream, the puddle, and even the well in the farmyard should be carefully guarded against infection. In general, any disease which can infect animals by entrance through the mouth into the alimentary canal may be transmitted by contaminated water, for example, glanders, strangles, internal parasites, and infectious abortion. By providing clean, fresh water, preferably from deep wells, losses from diseases conveyed by water may be largely eliminated.

The unrestricted dog has been shown to be responsible in some instances for the spread of foot-and-mouth disease, hog cholera, and other diseases, not only from one farm to another, but from one state to another. Dogs are the sole carriers of the virus of rabies, a fatal disease of both man and the domestic animals. As hosts of certain parasites which produce great damage in other animals, such as "gid," "measles," tapeworm and roundworm, dogs must be carefully considered when an attempt is made to eliminate those agents that spread disease.

No system of disease-prevention can be successful unless recognition is taken of those animals which have had an infectious disease. For example, cows which have had contagious abortion and apparently recovered, may yet actually be giving off in their se- and excretions the germs of the disease. Such individuals are known as "carriers." It is not only very difficult but often impossible to discover these "carrier cases." However, recently perfected biologic laboratory tests, which make use of the blood as a diagnostic agent, are proving very helpful in picking out those animals that are dangerous to their stable-mates.

(4) **The Removal of Infected Animals.**—The first step in preventing the spread of an infectious disease is to remove all affected animals to a place where they may be kept segregated. This is to prevent communicating the infection to others. In order to discover animals that are affected, the knowledge possessed by an experienced veterinarian is needed. Even he does not rely upon a physical examination, but will bring to his aid special instruments and biologic diagnostic agents. The most commonly employed biologics of this kind are tuberculin for the diagnosis of tuberculosis, johnin for Johne's disease, and mallein which shows whether an animal has glanders. When properly used, these preparations are capable of determining cases of disease in the very earliest stages and before external symptoms are evident. None of them is harmful if used according to approved methods.

(5) **The Establishment of a Quarantine.**—By quarantine is meant the limitation of freedom of movement of animals that have been exposed to a communicable disease for a period of time equal to the incubation period of the disease to which they have been exposed. Measures that are designed to safeguard against the spread of disease and are useful in preventing diseases from getting a foothold are the basis for the establishment of a quarantine. To be effective, a quarantine should include both the infected and the exposed animals. The infected animals should be surrounded by barriers to take care of the excreta and contaminated litter, and should have a trained attendant who understands and will observe the necessary precautions against the distribution of disease and see that others also observe them. If this is not convenient, the attendant should be provided with a change of clothing, more especially shoes and overalls. The exposed animals should be prevented from contact with flies, provided with good water and feed, and confined to a clean, well ventilated stable.

During the quarantine period disinfectants should be used freely. In case an animal dies, especial precautions are to be exercised to sweep, wash, and disinfect the place where it was kept and to burn the litter.

An official quarantine is issued by order of federal or state live stock sanitary officials, but cannot be effective unless public sentiment is back of the order. Strong coöperation among

live stock owners in the community is necessary if a quarantine is to check the ravages of disease.

It is essential that a quarantine be continued until all danger of spreading disease is passed. If it is lifted too soon no more benefit follows than if it had not been enforced.

(6) **The Cleaning up of the Premises.**—Disinfection is the chief weapon of the sanitarian for making infected premises safe.
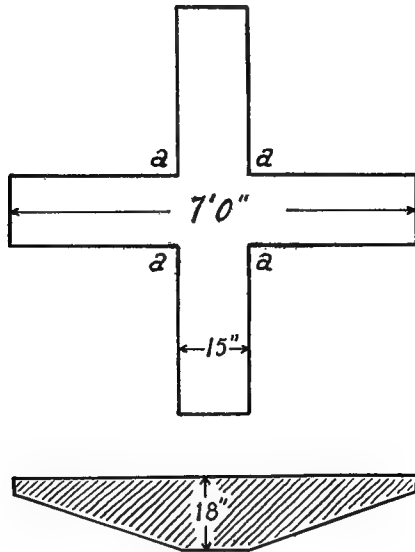
FIG. 61.—Sketches to show how trenches should be dug to cremate a large animal in the open.

To be effective the disinfectant must come in actual contact with the material which is to be disinfected. The ideal disinfectant is one which will destroy the germs without injury to the object. Some disinfectants are less poisonous to animals than others. There is no one agent applicable in all cases, therefore the conditions must be studied in each case and the most suitable disinfectant selected. The disinfectants in common use are heat, cold, chemicals, fumigation, and sunlight.

Heat in the form of fire is the most valuable and reliable means of destroying bacteria. When the object can be destroyed, it is

the ideal agent to employ. Cremation in the field of the carcasses and excreta of animals that have died from an infectious disease, is carried out by digging two trenches at right angles to each other in the shape of a + (Fig. 61). Each trench is 7 feet long, about 15 inches wide, and 18 inches deep at the center, where the two meet, becoming shallower at the ends. The earth is thrown into the angles at aa. Two or three pieces of railroad rail or similar iron are placed across the trench for the body to rest on and to allow the air to circulate beneath the fire. Unless the animal has died from anthrax, a disease of man contracted from animals, it will be best to eviscerate the body and remove the limbs. Dry wood is laid on the grates. The body is placed on this wood, then another layer of wood, followed by the limbs, on the top of which the viscera are laid. By this method it is possible to consume the carcass of even a large animal in five or six hours. A few gallons of kerosene sprinkled over the material will facilitate burning.

Cold is less effective than heat as a disinfectant. In the northern states, where the winters are long and rigorous, most disease-producing microörganisms are unable to survive unless protected in manure piles and other places secluded from frosts. In some outbreaks of infectious diseases it has been observed that there is a tendency for them to "die out" in the winter. The action of cold is often accountable for this desirable turn, but too much confidence should not be placed in it, as certain spore-forming organisms like that of anthrax are not killed, besides there are many chances of introducing a fresh infection.

Chemical disinfectants are most commonly used about the farm because they are easiest to apply. Those that are the least poisonous to animals should be selected for direct application when the body is to be disinfected. It is impossible to state which is best, for the nature of the substance to be acted upon must be considered. Bichlorid of mercury, commonly called corrosive sublimate, is in favor with many. It has the power to destroy all forms of microbes in relatively weak solutions. It is a cheap, reliable, and easily handled disinfectant, but has the disadvantage of being very corrosive and extremely poisonous. Carbolic acid is commonly employed in a 5 per cent. solution in water. It does not injure clothing, metals, or wood, and does not coagulate albumen so readily as bichlorid of mercury.

On the other hand, carbolic acid is not so reliable as some of the other disinfectants on the market. Coal-tar derivatives, under various trade names, are useful, but the phenol coefficient or germicidal capacity of each should be obtained from a trustworthy source before reliance is placed in them, as their disinfectant properties vary widely. Best results are obtained when a solution is being made, if the water is added to the coal-tar product rather than vice versa.

Fumigation is the process of destroying germs and insects by the employment of poisonous gaseous agents. It is impracticable in most cases on account of the impossibility of making the building airtight. When this can be done, formaldehyd or carbon disulphid may be used to fumigate.

Sunlight is the disinfectant provided by nature. It reduces the vitality of all germs and actually destroys many kinds. When it is admitted freely to the stable, it prevents both the contracting and spread of disease. Reliance, however, should not be placed entirely in sunlight as a destroyer of bacteria, but it is effective as an accessory to the other agents mentioned above.

(7) **Deep Burial.**—This method may be used to dispose of animal carcasses. The precaution of digging the grave deep enough so that dogs and other animals cannot exhume the carcass must be taken. Sprinkling the remains with quicklime before covering with dirt is an additional safeguard.

(8) **The Use of Conditioners.**—Conditioners are agents that aid in maintaining the animal's condition by stimulating the appetite and keeping the stomach and bowels free from worms. They should be kept in covered boxes and within reach of all animals when they are turned out in the yard or pasture. The principal ingredients of most conditioners are salt and charcoal. The following formula has been used with success at the Wisconsin Argicultural Experiment Station: Common salt 280 pounds, dried iron sulphate 16 pounds, powdered wood charcoal 12 pounds, flowers of sulphur 8 pounds. These materials should be well mixed or ground together to make a powder.

(9) **The Slaughter of Infected or Exposed Animals.**—This is the so-called stamping out method by which infectious diseases may be controlled or eradicated when the methods previously mentioned are impracticable or impossible to carry out. In cases of disease which terminate fatally in the majority of instances,

slaughter does not imply any great sacrifice, but in other infectious maladies which ordinarily end in recovery, segregation would in most outbreaks be substituted. Fortunately for the owner of live stock, the state and nation have provided for reimbursement of animals slaughtered by the live stock sanitary authorities. In some states the full appraised value is allowed; in nearly all a reasonable allowance is made. This method is most effective when a rigid quarantine is enforced at the same time. As a means of coping with foot-and-mouth disease and other epizootics in the United States and Canada, it has been used very successfully.

THE TREATMENT OF DISEASE

Treatment consists in removing the cause of disease and in supporting nature in her endeavor to combat the malady. The science and art of healing is termed *therapeutics*. It deals with all the curative forces employed in the treatment of disease.

The first questions to be considered in outlining a course of treatment are: Can the disease be left to nature's care? Is medicinal treatment needed or desirable? Is surgical treatment indicated? If we decide to lend aid, then we must determine when to help and when to hinder nature's curative processes. How to help without doing harm is a question of prime importance, which must be answered before treatment is begun. It always calls for mature judgment.

In general, it may be said that treatment must be instituted early in the course of a disease—that is, before the pathologic changes have become marked and the natural processes inhibited —if the best results are to be expected from it. Furthermore, the animal should be placed under the most favorable conditions for recovery and the medicines selected should be of accurate strength, proper dose, best quality and pushed to the desired effect, with all adjuvant treatment that it is possible to supply.

A careful study of the causes of disease and the symptoms exhibited by the patient, as previously explained, should give the stockman a basis upon which to work, and indicate to him the best method to pursue to remove the exact cause of trouble, without which only imperfect results from any line of treatment should be anticipated. It should be remembered that the body itself contains or manufactures the substances necessary to

restore health, and all that medicines and other remedies can do is to appeal to and arouse the body to action.

As animals are often killed by the attendant giving too large, too frequent, or too strong doses of medicine, one should be careful and not attempt to do too much. It is always best to summon a veterinarian, as his advice is based upon experience and scientific training and is the best obtainable. Remember at all times that the animal does not differ materially from man and that it reacts in much the same way to medical treatment. So stop and consider the consequences of giving strong medicines to yourself before administering them to your animals. The same principles for the treatment of disease apply in veterinary practice that are employed in the practice of human medicine.

In the treatment of disease, the first concern of the average person is to find a cure or remedy. Unfortunately, there are but few diseases for which curative agents are known. This is particularly true of infectious diseases. Modern research has shown that many diseases which are highly mortal and cannot be cured by any known means may be prevented. There has accordingly been developed in the last few decades a system of treatment that, while not strictly curative in its nature, brings disease under control. It is known as preventive treatment, the principles of which were discussed in the preceding section. In many cases a clear line can scarcely be drawn between the two, but this makes no difference so long as beneficial results follow their application.

Nature may be supported in overcoming disease by those things which are available in almost every stable. It is not so much what is used, as how it is used. First-aid treatment should not call for expensive and rare equipment, but the intelligent use of the means at hand. However, to be effective, treatment must be of a kind particularly suited to the case. In many cases ultimate success depends upon the selection of a special therapeutic agent the lack of which is likely to result in death. For example, the specific remedy for tetanus is tetanus antitoxin, that for hog cholera is anti-hog-cholera serum, and that for actinomycosis or lumpy jaw of cattle is iodin. No other remedies are nearly as effective for these diseases as the ones mentioned.

Remedies for the treatment of diseases include a large number of agents. The term "remedy" is used here in a comprehensive

sense, and does not signify the same thing as medicine or drug, but comprises all therapeutic aids used to cure disease and to promote restoration of health.   Those of most importance are nursing, stable quarters, clothing, food, water, rest, exercise, and surgical operations, as well as medicines.

(1) **Nursing** is just as essential in the treatment of a sick animal as in that of a sick person.   When rendered in a sensible manner it hastens recovery and fits the animal more promptly for return to service.   A competent nurse is one capable of giving intelligent care.   He should be observing enough to anticipate changes for the better or worse in the patient, and to provide comforts before they are absolutely necessary.   In such diseases as colic, when the horse is in the throes of acute pain and rolls or throws himself, a nurse should be in constant attendance to prevent the animal from seriously injuring itself. Among the duties of the nurse is that of caring for the skin.   This includes both washing and grooming.   A sponge-bath removes accumulated sweat and other skin excretions.   In the summer, bathing in a lake or river is an ideal way of procuring the same benefits.   Grooming keeps the pores of the skin from clogging with dust and dandruff and makes this important excretory organ more active in disposing of wastes.   When combined with vigorous rubbing, grooming imparts to the muscles all the benefits of massage.   The curry comb, dandy brush, and wiping cloth should be used daily.

(2) **Stable quarters** suitable for the particular patient should be provided.   A large, airy box stall, which has been freshly cleaned and whitewashed, ought to be available for emergency cases.   Good light, freedom from drafts, and bedding of a loose texture, such as straw, sawdust, or shavings, are all important details to be looked after when preparing a place for the sick animal.   Patients suffering from a nervous disease, like tetanus, need quiet, so should be shut away from noises and other annoyances in an enclosed stall.   Darkening the windows of the stall will be found helpful in caring for nervous animals, and in summer has the additional advantage of keeping out flies.   A temperature of 45° to 50°F. is best for most housed animals in the winter. When necessary, artificial heat should be provided.   The humidity of the air also should be regulated.   Before being used again the sick stall should be thoroughly disinfected to destroy

any disease-producing germs that its previous occupant may have left.

(3) **Clothing** consists of blankets, hoods, and bandages of various kinds. Woollen blankets are best in the winter to protect the animal from exposure. In the summer light cotton sheets are useful in affording protection from the attacks of flies and other biting insects. A specially designed hood is useful in throat and lung diseases to protect the head and neck. Too much covering is detrimental to health, and should be avoided, for the skin will be hindered in performing its functions of an excretory and temperature equalizing organ. Damp, foul-smelling horse clothing is harmful, so care must be taken to air and dry it each day. Bandages protect, warm, and support the legs. Those made of flannel are preferable. The woven cotton, or Derby bandages, possess much elasticity and are very serviceable. Bandages should be changed several times daily, and at each change a thorough hand-rubbing given the legs to stimulate the circulation of the blood. At the same time the application of a mild, stimulating liniment, composed of equal parts of alcohol and witch hazel, may be made. Strong liniments applied under a bandage will blister. When applied to the legs, bandages should be rolled from below upward so as not to impede the flow of blood in the veins. Care should be taken that no wrinkles are left to cause unequal pressure and interfere with the circulation. If a bandage is too tight a ring-like swelling appears above and below it.

(4) **Food** for sick animals should be selected very carefully, and fed at regular intervals. Only sound, easily digested food, given in small quantity and at frequent intervals should be offered to sick animals. Digestive disturbances can be materially alleviated by withholding feed for ten or more hours. Smith says that, instead of forcing food on a horse which is "off his feed" from overwork and giving him stimulants, it is much better to allow him a full supply of drinking-water and some green food or carrots, so as to facilitate the removal from his system of the deleterious products that are the cause of his depression. When they have been excreted, his system will demand materials for repair, with the result of healthy general stimulation. On the other hand, animals suffering from debilitating diseases should be tempted with appetizing food of an

easily digested and nutritious nature, as good food plays an important part in the treatment of sick animals, building up the weakened and wasted tissues. Turning out to pasture is an excellent means of providing a change in the ration and will certainly bring gratifying results.

Green foods are valuable because they are easily digested, contain much water, and are rich in mineral matter. They keep the bowels loose and the liver at its work of eliminating wastes from the body. When the liver fails to function properly the whole system becomes clogged and sluggish and generally out of order.

Food should be offered sick animals only in small quantities, as the patient will usually have a poor appetite, and any portion left over soon becomes tainted with stable odors, which render it unpalatable. When such food is left before the patient for any length of time it will have a tendency to take away all appetite. The best way to increase the appetite of a horse is to change the character of his feed frequently. Food that is wet, such as bran mashes or steamed oats, will soon sour in warm weather, or will get cold in the winter. Colic and diarrhea often result when food of this character is eaten. Feed which has been slobbered on undergoes fermentation very rapidly. As has been said this is due to the action of the saliva upon the food constituents. Food should not be forced upon a sick animal, for we should remember that the state of his appetite is the best guide by which we may know whether his system requires food. Appetite is regulated largely by the physiologic needs of the body.

Common salt, according to Kellner, exerts a physiologic action in digestion by serving as a spice or condiment which stimulates the appetite and increases the palatability of the food. It also stimulates the secretion of the digestive juices, increases and hastens their action, and prevents digestive disturbances. As a complement to the food of the sick it is of prime importance.

(5) **Water** should be kept constantly within reach of a sick animal for there is nothing which is more beneficial and conducive to health. It should be pure and fresh. The animal will often rinse out his mouth, and if suffering from a feverish condition will find much relief even if not thirsty. When allowed to stand about for any length of time water becomes flat. Drinking-

water should be curtailed if diarrhea is present. The warming of water in winter is recommended for sick animals, as ice-cold water is harmful. Water as a diluent of the digestive fluids permits them to come in contact with and thus act more efficiently on foods; the softening materially assists in the processes of mastication, digestion, absorption, and assimilation. Water dissolves nutrients; no foods can be utilized by the body that are not in water-soluble form. Furthermore, it is useful in eliminating nitrogenous waste from the body through the skin, kidneys and digestive tract. Medicines should not be given in the water unless they are tasteless. As a rule, it is safe to allow animals all the water they desire to drink.

(6) **Rest** must be insisted upon as an adjunct to other lines of treatment if a rapid recovery is desired. It includes the removal of the saddle if a saddle-gall is present, withdrawal of the nail in nail prick, change of the ration or withholding it in indigestion. Animals recovering from disease need more rest than other animals. After a long shipment or extreme physical exertion horses rest by taking the weight off one leg and then another. Growth is predominantly a function of rest, while work is chiefly an energy-expending and tearing-down process. Work may furnish the conditions under which subsequent growth may occur, but in itself it is destructive. By work we do things in the world, but we do not grow by work; we grow during rest. It is not the only condition of growth, but it is one of the essential conditions.

(7) **Exercise** is as important in the treatment of disease as rest and proper feed. By stimulating the heart and muscles to action it causes the blood to flow more freely through the body and hastens recovery by keeping a supply of nutrients on hand and taking away the tissue débris. It should be given daily, and in moderation, unless the patient is suffering from a disease accompanied with a high fever, or is undergoing treatment involving immobility of a certain part, when better results will be had from absolute rest. Yard or halter exercise is especially recommended, as it gives an opportunity for the animal to get a supply of fresh air. The value in turning to pasture is largely that derived from exercise. Denied exercise even the most robust animal sooner or later loses health.

(8) **Surgical operations** are often resorted to for the treatment of disease. They are successful only when skillfully performed

and when the surgical wound is properly cared for. Many diseases that even a few years ago were thought to be incurable are now amenable to surgical relief. For the removal of tumors and foreign bodies, and in the treatment of many other diseased conditions, this method of treatment is the only one that is capable of bringing about a cure. Surgery is a method of treatment that should greatly interest every live stock raiser as by its means valuable animals can be saved that would otherwise be lost.

(9) **Medicines** are agents of vegetable, mineral, and animal origin used for the cure of disease or the relief of pain. They are substances that exert influence over one or more of the functions of the body. The study of the derivation, physical and chemical properties, physiologic actions, and doses of medicines is known as materia medica.

Many of the medicines which have been in use for centuries are now known to be of little or no value as remedies for the diseases in which they have long been applied. Upon careful inquiry into the reason for their having been recommended originally, it was found that superstitious belief in signs and symbols was responsible for the use of many. To illustrate, bloodroot, on account of its red juice, is even today considered to be good for the blood; eyebright, being marked with a spot like an eye, was accordingly just the thing for sore eyes; liverwort, having a leaf shaped like the liver, was thought to be a sure cure for diseases of the liver; bear's grease, coming from an animal thickly covered with hair, was recommended to stimulate the growth of hair. Red flannel bandages are given preference to those of other colors because they look like blood and therefore are thought to have curative properties for rheumatism and other blood diseases.

Entire reliance should not be placed in medicines any more than in any other of the therapeutic aids that have been mentioned, for each is dependent on others to accomplish a cure. When any one of these aids is lacking, treatment may fail miserably. The big task is first to select and then to apply the medicines to the disorders which they are capable of correcting.

Medicines of vegetable origin comprise a large group of very great importance. The leaves, bark, roots, flowers, fruit, and seeds are used, depending upon the nature of the plant. Although powdered preparations of the above are frequently employed in

veterinary practice, various extracts of these plant parts are used more generally. These extracts are known as tinctures and fluid extracts and differ primarily in the quantity of the active medicinal principles which they contain, the fluid extract being the stronger. The active medicinal principles of all vegetable drugs are known as alkaloids. These represent but a very small proportion of the crude drugs. When isolated in a scientific manner the alkaloids have the following advantages over the ordinary fluid or dry preparations: (1) greater accuracy in the dose; (2) greater dependability in action; (3) greater convenience in application; (4) quicker results due to their more rapid absorption.

Some live stock owners object to their veterinarian using active principles of drugs on the grounds that the amount given is so small that it can seem to have little effect. This objection has absolutely nothing to justify it. What the owner really wants is results. Experience has taught him that the old practices of giving violent purges and bleeding to excess seldom bring results. He should, therefore, welcome more effective methods of treatment and encourage his veterinarian to use them.

Medicines of mineral origin represent many combinations. The salts of sodium, potassium, calcium, magnesium, ammonium, and iron are most often employed. These salts are found in the body tissues and are essential to the life of the animal, which accounts for their general use as therapeutic agents.

Medicines of animal origin are not so numerous as either vegetable or mineral drugs. They include such agents as pepsin, pancreatin, adrenalin, pituitrin, and thyroidin which are all manufactured from glands with similar names. These preparations should never be used without the sanction of a competent veterinarian as they are contra-indicated in some cases and would cause serious trouble.

Biologic preparations of various kinds have come into extensive use within the last few years. They are a most valuable contribution to the healing art and are constantly being perfected. To be of most value, the biologics must be administered before infection occurs. This is because they act largely as preventives, although some have decided curative properties. It should be understood that they are not used to replace but to supplement other preventive and curative treatments.

15

In the preparation of these biologic therapeutic agents, it is essential that the organism that causes the disease be used. When prepared with skill and applied to cases where they are certainly indicated, they will yield good results because of their specificity. The three classes of biologics that are used the most are: (1) vaccines, (2) bacterins, and (3) sera.

Vaccines are agents containing living virulent bacteria, or bacteria that have had their vitality and virulency reduced by heat or chemicals. They are used purposely to produce a mild attack of disease, thereby rendering the animal resistant when subsequently exposed to a natural infection. Examples are blackleg and anthrax vaccines, which are extensively and successfully used throughout sections where these diseases are prevalent.

Bacterins are similar to vaccines except that the bacteria in them have been killed and cannot produce disease even in very large doses. When introduced into the body they stimulate the production of protective substances which act against subsequent attacks of the particular virulent germ. Examples of bacterins in common use are those for influenza and suppuration in horses, and distemper in dogs. Theoretically, bacterins should be useful in the treatment of every infectious disease of which the causative organism is known. Practically, they do not always give desired results, as it is impossible to immunize against many chronic infectious diseases.

Sera for therapeutic use are obtained from the blood of animals that have received one large or several smaller doses of infectious organisms. As a result of this treatment, specific antibodies are produced in large quantities in their blood. These antibodies exert a bactericidal action on virulent organisms, or contain antitoxins that will neutralize bacterial toxins. When used alone they can only tide the animal over the period of exposure. When used in conjunction with living germs the production of antibodies is stimulated to such an extent that the animal is rendered permanently immune. Examples of specific sera that have proved successful are those for hog cholera, tetanus, rinderpest, and calf scours.

The process of conferring protection by treatment with these biologic products is spoken of as immunization. Immunization is recommended either when other methods of prevention are impracticable, or when it is desirable to strengthen the body

against a particular infection. So far it has been possible to prepare reliable immunizing products only against those diseases that produce rather powerful toxins and that run a more or less acute course.

An attempt to confer immunity is not always successful. In some cases the animal may succumb to the disease after it has been treated, or die as a result of complications of the disease. This is due to (1) the animal being already infected when treated; (2) insufficient or impotent immunizing agents; (3) improper administration of the immunizing agents; (4) infection with other germs of disease after the immunizing treatment has been given.

The veterinarian has certain legal responsibilities when he answers a call to treat a sick animal, for he enters into an assumed contract with the owner. He warrants, according to Hemmenway, the following:

1. That he is legally qualified to practice his profession.

2. That his educational training and experience enable him to treat the case in accord with the known facts of science.

3. That he will continue to care for the case, and render such service as may be needed until the case shall be terminated, either by the death or recovery of the patient, or by the proper severing of the relationship existing between himself and the owner.

4. That he will employ approved methods of practice.

5. That he will use due care and diligence. Moreover, unless especially provided, the veterinarian will not be deemed to have guaranteed a cure.

The owner of the sick animal agrees on his part:

1. That he will follow all reasonable directions of the veterinarian and render such assistance as may be possible.

2. That he will pay the veterinarian such reasonable fee as would be approved, considering the services rendered, by the customs of the community.

THE TERMINATION OF DISEASE

Convalescence is the period between the removal of actual disease and recovery of health and strength. During this period it is highly important that the animal does not overdo, for its strength and power of endurance are reduced. Without doubt, many horses, which would have made a complete recovery from

disease if they had not been put to work too soon, have succumbed during the convalescent period.

Disease may terminate in one of the three following ways:

(1) **Complete recovery** occurs if the natural, defensive, and reparative powers of the body are capable of neutralizing the poisons, eliminating débris, and repairing the tissues. Complete recovery from disease is known as resolution. It may occur early in the attack or not until very late.

(2) **Incomplete recovery** follows after a disease has run its course and left some permanent impairment of tissue (sequelæ of disease); for example, adhesion of the lungs after pleurisy; opacity of the previously transparent part of the eye; deformities of bones. Many times the organ will be, for all practical intents and purposes, as serviceable as before.

(3) **Death** occurs when the vital organs suspend their functions. It is brought about by the failure of either the respiratory, the circulatory, or the nervous functions, or it may be due to a complication of these causes. In the case of many infectious diseases, in which the organisms gain entrance to the blood stream, death is due to a combination of physical and chemical effects. For example, the bacteria may clump together and stop the flow of blood in certain capillaries; the bacterial toxins may poison the tissues to a point where they are rendered inactive; the leukocytes may become paralyzed; the antibodies may become exhausted. Death may occur suddenly, in which case the animal collapses, becomes unconscious, and for a few moments at most is thrown into convulsions, as in lightning-stroke or sunstroke. In the majority of cases death comes on gradually, and terminates in the so-called death agony or death struggle. This mode shows progressive paralysis of the different systems of body organs. Animals in the agonal state are unable to rise, lie flat on one side, and lift the head from time to time and let it fall heavily. They may sweat profusely and involuntarily void urine and feces.

GENERAL PATHOLOGIC CHANGES

DISEASES OF THE BLOOD

General disturbances of the health are accompanied by changes in either the distribution or the composition of the blood, or both. When the various functions of this highly important fluid are recalled, it is readily understood why any alteration in it endangers both life and health.

Normally, both the quantity and quality of the blood are maintained at a point just high enough to meet the requirements of the body. When the demands for blood are great in one set of organs as a result of increased activity, there is corresponding increase in action on the part of the heart to supply the demands.

Various diseased conditions of the blood are recognized. Many of the terms used for them end in "emia," which signifies blood. For example, there are hyperemia, anemia, hydremia, septicemia, pyemia, and sapremia, each of which will now be briefly discussed.

Hyperemia or congestion is applied to an increase in the quantity of blood in a part. When it is not marked it is normal; for example, a flush of the face from embarrassment. When pronounced and long continued it is a sign of disease. It may be either active or passive.

Active hyperemia is the condition in which the arteries are overfilled with blood. It is caused by agencies which produce an increased flow of blood in the part, such as mechanical and chemical irritants. The part appears slightly larger, redder, and warmer than normal. These changes are due to the fact that the blood is prevented from circulating as it should; for example, congestion of the udder. Long-continued congestion leads to permanent enlargement of the part. Fortunately, it is usually temporary, so permanent injury rarely results unless complications take place. Active congestion is seen in inflammation of which it is always a symptom.

229

Passive hyperemia is an overfilling of the veins with blood. The affected part becomes larger and bluish-red in color. In most animals the color cannot be seen, as the skin is pigmented. The "stocking" or filling of the legs is a form of passive congestion. It may be prevented by hand-rubbing and applying bandages to the legs as soon as the horse returns from work. A laxative diet should be provided for such animals. The swelling which occurs along the belly of a mare a few days or weeks before foaling is another example. It is due either to a compression of the walls of the veins, so that blood cannot circulate freely through them, or to weakened heart action. The large milk veins of some cows are often in a state of passive congestion due to a damming back of the blood into them. In such cases they are not an index to the quantity of milk which the animal is capable of producing. Long continued or sudden and complete passive congestion causes the blood to stagnate and its watery constituents to exude through the vessel walls into surrounding tissues.

Anemia is the opposite of hyperemia. In this condition there is either a diminution in the quantity or quality of the blood or both. It may be either general or local.

General anemia is due to a deficiency in the total quantity of the blood. It is caused by excessive hemorrhage, poor nutrition, or anything which destroys the red blood-corpuscles, particularly parasites. Animals suffering from general anemia are said to have "thin blood," their mucous membranes are pallid, and they are listless.

Local anemia is that condition in which there is less blood in the part than normally, but the total amount of blood in the body is not reduced. It is brought about by (1) pressure on the part; (2) a thickening in the wall of a blood-vessel; (3) partial occlusion of the artery to the part; (4) cold and chemical agents; (5) congestion of blood elsewhere in the body. The part affected feels cooler and is paler than normal. If long continued, death of the part takes place from lack of blood supply.

Hydremia is an increase in the water content of the blood. It is not a very common disease so needs but passing mention.

Septicemia is a morbid process in which septic or poisonous substances are present in the blood. When toxins only are present, the condition is termed *toxemia*. In most cases bacteria

are also present and may be cultured.   This condition is called *bacteremia*.   Both of these conditions are observed in a large number of infectious diseases, *e.g.*, anthrax and strangles.

Pyemia refers to the presence in the blood of pus-producing organisms which congregate to form multiple abscesses about the size of a pea in different organs of the body.   It often follows septicemia so is considered a secondary disease.

Sapremia is the result of absorption of poisonous putrefactive products derived from the destruction of necrotic tissues, *e.g.*, gangrene and retained placenta.

Dropsy is a pathologic condition closely associated with alterations in the blood.   It may be defined as a collection of an excessive amount of a watery, straw-colored fluid in any body cavity or tissue.   The horse is less commonly afflicted than sheep and other animals.   Two common forms of dropsy are ascites and hydrothorax.

Ascites is an accumulation of dropsical fluid in the abdominal cavity.   It is caused by anything that interferes with free circulation of the blood, so that the blood is dammed back into the veins.   The fluid constituents of the blood escape through the uninjured vessel walls.   Anything that alters the character of blood or destroys the corpuscles may be responsible for ascites.   The chief symptoms are distention of the belly and marked swelling of the limbs.   Treatment consists in abundant, nutritious food, iron tonics, and drugs to act on the kidneys to induce the urine to flow more freely.   Tapping the animal to permit the fluid to escape is often necessary, but affords only temporary relief.

Hydrothorax is a complication of certain forms of pleurisy. It is characterized by an accumulation of fluid in the thoracic cavity.   When present, this form of dropsy may be diagnosed by tapping the lower part of the chest wall.   If the ear is placed over the chest a sound resembling that of drops of water falling into a well may be heard.

INFLAMMATION

Inflammation is the one constant factor in all pathologic changes.   By its aid the body overcomes disease, heals wounds, and unites fractured bones.   It is a complicated process accompanied by changes in both the blood and cells of the affected part.

It is the reaction which living tissues show almost immediately to an injury or an irritant.

The term irritant may be best understood by first learning what is meant by a stimulant. A stimulant is anything that produces action in a living tissue, like the application of a mild liniment to the skin. When excessive stimulation is applied, like a very strong liniment or blister, irritation or injury results. Irritants and stimulants, therefore, differ only in the degree of action which they produce in the tissues.

The changes in inflamed tissues consist of a series of processes entirely similar to those taking place under normal conditions, only in more marked degree. Much blood is brought to the part. Besides nutritive substances, the blood brings a whole army of leukocytes to attack the irritant, neutralize its poisons, and prevent further injury.

The **causes of inflammation** include a great variety of mechanical, thermic, chemical, electric, and infectious agents. When these agents produce injuries they always destroy some cells. The dead cells act as irritants, consequently they set up an inflammation. The first four of these causes may be classed as nonbacterial in character, and produce an *aseptic* or *non-infectious inflammation*. The infectious agents consist of microörganisms which set up a *septic* or *infectious inflammation*. When the virulence of the invading bacteria is great, there results a rapid general infectious process with fatal termination; on the other hand, when the microörganisms are of low virulence, there occurs a slowly developing inflammation, which may be overcome by the bactericidal substances of the body before much damage is done.

The **kinds of inflammation** depend upon the character of the exudate produced. The simplest kind is a *serous inflammation*, in which a watery exudate like the contents of a water-blister is formed. A *suppurative inflammation* is accompanied by the formation of pus; a good example is an abscess. A *productive* or *proliferative inflammation* is the kind most common in bone tissue, like ringbone and spavin growths. *Croupous* and *diphtheric inflammations* occur on mucous membranes.

The **course of inflammation** is determined by the rapidity and intensity of the process in the inflamed tissue, and may be either acute, subacute, or chronic.

The **symptoms of inflammation** are heat, redness, swelling, pain, and disturbed function. *Heat* is mostly due to an increase in the amount of blood flowing through the part. *Redness* is observable only in white-skinned animals, and is due to more blood than normal in the part; however, inflamed mucous surfaces in all animals readily show it. *Swelling* is the result of the same cause plus the inflammatory exudate or fluid which oozes out of the blood-vessels to bathe the tissues. *Pain* results from undue pressure on the sensory nerves. *Disturbed function* is seen in all active tissues when they are inflamed.

The **treatment of inflammation** should be directed toward assisting the body in its endeavors to remove the irritant cause. In case the inflammation is of an aseptic nature, treatment will be largely symptomatic. When sepsis is present the mode of procedure must be varied to suit the particular case. Local remedies for the treatment of inflammation are rest, heat, cold, massage, counterirritants, and antiseptics.

Rest is most important, for it involves removal of the irritant and supports the action of other remedies. It is particularly essential in all painful conditions, such as lameness and rheumatism.

Heat is indicated only in cases where no bacterial infection is present. It stimulates the circulation, and thus promotes the absorption of the exudate and hastens the elimination of the waste products. Under the influence of heat the tissues relax, so that pressure is taken off the sensitive nerves and pain is relieved. It is applied in the form of hot packs, hot air, and poultices.

Cold is useful in the first stages of acute inflammation and in septic conditions. It contracts the tissues and lessens the vitality of the part. No fixed rules can be laid down for its application. In practice cold is applied in the form of cold water or ice-packs.

Massage is an important adjunct to healing in non-infectious inflammations, but is contra-indicated in septic conditions, as it tends to relax the tissues and thus allows resorption of toxic products. It is applied by rubbing, stroking, and kneading the part.

Counterirritants are used for deep-seated inflammations. They stimulate blood circulation and are very important aids in

veterinary medicine. They are applied as liniments, blisters, or the actual cautery in the form of the firing iron, to hasten the process and promote healing by transforming a chronic into an acute inflammation.

Antiseptics are valuable in treating septic inflammation. For this purpose camphor, carbolic acid, and iodin are especially recommended. (See wound treatment.)

The **termination of inflammation** depends upon the amount of injury to the tissues. When the irritant is removed and the inflammatory product is entirely absorbed, resolution follows and the part fully regains its normal functions. The production of new growths, adhesions between organs, and the retention of an exudate in a cavity are other forms in which inflammation may terminate, but they always interfere more or less with the functional activities. In severe disturbances of the circulation gangrene or death of the tissues occurs.

FEVER

Fever, like inflammation, is to be regarded as a natural reaction of the body designed for protection. It is a symptom of disease rather than a specific affection. All infectious diseases are ushered in with a rise in the body temperature, which makes this symptom the most reliable guide for the diagnosis of diseases due to germs.

The **cause of fever** is not definitely known. However, any disturbance in the *thermal nerve-center* at the base of the brain may result in elevation of the body temperature. This center is not under the control of the will, but responds quickly to every change in the surrounding temperature, as well as to influences arising within the body such as muscular activity and nervous excitement. It harmonizes the forces for heat production, heat dissipation, and heat regulation. When the products of bacteria or the organisms themselves gain entrance to the fluids of the body, they deaden the thermal center and prevent it from functioning. Examples of infectious fevers are those caused by the microörganisms of strangles and glanders. In other cases fever occurs without the intervention of bacteria from the resorption of products resulting from the disintegration of blood, painful conditions, rheumatism, fatigue, and overheating.

The **kinds of fever** are determined by the height of the temperature. We speak of a mild fever, 101.5° to 103°F.; a moderate fever, 103° to 105°F.; a high fever, 105° to 106.5°F.; and a very high fever when the recording thermometer registers 106.5°F. or higher. An infectious fever is the kind that accompanies infection of the body.

The **symptoms of fever** include a rise in the temperature, changes in the secretions and excretions, a rapid pulse, accelerated respirations, dilated nostrils, a hot dry skin, increased thirst, loss of appetite, and digestive disturbances. Sometimes chills are evident at the onset of fever, causing the patient to tremble and shiver throughout the body. Chills are accompanied by erection of the hair coat and a cold skin. These changes are due to a congestion of the blood in the internal organs which leaves the surface of the body cold, but causes elevation of the internal temperature.

The **crisis of fever** is the turning-point when the temperature falls abruptly. Often the crisis is accompanied by critical discharges, such as critical profuse excretion of urine, critical diarrhea, or critical sweat. A day or two preceding the crisis the temperature drops almost to normal, but immediately goes up again. This is the pseudo or false crisis. Before crisis occurs the temperature is higher than at any other time during the disease. This is the period of critical change. Animals often die when the temperature has reached its lowest point. The decline of fever preceding recovery is believed to be due to the formation somewhere in the body (bone-marrow, liver, or spleen), during the febrile process, of a large quantity of protective substances (antibodies), and to the destruction of the fever-producing substances present in the system from the time when the protective substances predominate.

The **prognosis of fever** should be guarded, for we find that recovery from diseases accompanied with high fever is quite slow, because the body must replace the large amounts of tissues destroyed by the extreme oxidation. The age, vitality, and care given the patient are important aids in determining the outcome.

The **course of fever** may be continuous, remittent, or intermittent. The body gives off more heat during fever than it does normally at rest, but not nearly so much as it does during active exercise. It is possible for heat production during exercise

to be increased 200 to 300 per cent., but such is the accuracy of heat loss adjustment that the temperature of the body remains normal. During fever, on the other hand, the production of heat is increased only 20 to 40 per cent., but the dissipation of heat is not proportional and therefore the temperature rises.

The **effects of fever** have been shown experimentally by keeping animals confined at a high temperature to cause their body temperature to rise. They were found to develop a much more effective defense against small but repeated doses of bacteria or toxins than control animals. They lived longer and many of them survived doses which killed the controls. This shows that moderate degrees of fever are beneficial and stimulative to the body.

The **treatment of fever** should be directed toward keeping it within bounds so as to prevent structural changes in the internal organs, which occur when it goes very high. Nature's method of combating fever is by decreasing motion and appetite, and increasing thirst. Means of promoting heat loss from the body consist in the use of agents to dilate the blood-vessels near the surfaces of the body, to increase the secretion of sweat, and to increase the number of respirations per minute. No matter what line of treatment is followed, the patient must be protected from draughts and kept warm.

Six ounces of Glauber's salts or frequent doses of sulphocarbolates will be found beneficial in the first stages of fever. These simple remedies help to reduce the temperature by emptying the intestinal canal, by hastening the elimination of infectious materials through stimulating the intestinal gland secretions, and by preventing bacterial action. Drastic purges should be avoided, as they are likely to set up a diarrhea which may be impossible to control. Various agents, known as antipyretics or febrifuges, are used to reduce the body temperature. They act either by preventing oxidation or stimulating the radiation of heat. Among the medicines commonly used to reduce fever are aconite and acetanilid, but they are dangerous in the hands of the inexperienced. Furthermore, little benefit follows their administration, because they act as poisons, not only to the heat producing and regulating centers, but also to other important centers, thereby lessening the natural resistance of the body and the activity of the processes of repair.

HYPERTROPHY

Hypertrophy is the enlargement of a part of the body.   The increased size may be due either to physiologic or pathologic causes.   In either case the part or organ involved takes on increased functional activity.   An example is seen in the case of a giant, where the condition is general.   Physiologic hypertrophy occurs because an increased demand is made upon the organ; for example, the muscles of a gymnast or the biceps of the blacksmith.   The heart shows the effects, especially in horses used for fast or very heavy work.   In these the heart is always much larger than in animals not placed under such strain.   Comparison of the heart from a dog with one from a sheep or pig of the same weight will reveal a decided difference, due to their mode of life.   If one kidney becomes diseased and cannot function, the opposite is increased to double the usual size (compensatory hypertrophy); but there is usually no indication of kidney disease observable during life.

ATROPHY

Atrophy is a wasting away or diminution in the bulk of one or more of the component parts of an organ, accompanied by a diminution in function.   It is the reverse of hypertrophy. Examples of atrophy are seen in the thymus gland of young animals, the uterus of old mares, and "sweeny" following injury to the shoulder muscles.   A peculiar form of this change is called "senile atrophy," noticeable in the sexual glands of the aged and prematurely aged.   Brittleness of bones in the old is another example.   Causes of atrophy include all those factors which interfere with the nutrition and activity of an organ. In starvation the fat of the body disappears and the organs atrophy, so that the animal may lose more than half in weight. Deficient nutrition, due to interference with the normal blood supply, may occasion atrophy.   This form is seen when the chief artery to a part is ligated.   Constant pressure inhibits growth and leads to a decrease in size, as may be seen in the deep groove left across the nose of a horse tied for a long time by a halter with a tight nose-band.   In old horses the liver is smaller than in young animals, due to long-continued pressure from other

abdominal organs. Continued lack of use causes an "atrophy of inactivity." It is observed in the muscles after prolonged fixation of a limb in splints. Massage or other methods of stimulating the circulation of blood is the logical basis of treatment.

CALCULI

Calculi are formed by the precipitation of salts which have become insoluble. They may be found in the intestines, kidney, or bladder. *Intestinal calculi* appear as rounded, stone-like bodies. They usually weigh from 2 to 3 pounds, although one horse is reported to have had a calculus weighing 16 pounds. *Renal calculi* usually occur as soft, mortar-like masses in the pelvis of the kidney, where they may be present for a long period without causing a visible disturbance. *Cystic calculi* form in the bladder from nuclei the size of grains of sand. They may grow by accretion until they are as large as a baseball. Some are quite smooth externally, others are very rough, and continually irritate the bladder, causing the horse to urinate at frequent intervals. Solvents for cystic calculi are not very successful. Operative treatment by which they are completely removed is the only satisfactory method in handling these cases.

CONCRETIONS

Concretions are formed of closely packed undigested vegetable matter and are found only in the digestive canal. The hair-like processes on the stems and heads of crimson clover which has been allowed fully to mature before cutting may form "hair balls" when eaten by horses and mules. To avoid this trouble such hay should be fed in small quantities or mixed with other hay. If it is sprinkled with water twelve hours before feeding the claim is made that the danger of hair-ball formation is considerably reduced. True hair balls are composed of hair; they are often found in cattle. A physic administered with strychnine to stimulate bowel activity is the best treatment.

CYSTS

A cyst is a pathologic cavity provided with a distinct membrane enclosing fluid or semifluid contents. It is a secondary formation.

The following kinds of cysts are recognized: (1) **Retention cysts,** which occur when the characteristic secretions of glands accumulate in the ducts of the glands.   The cause of their formation is obstruction to the outflow of the fluid due to stenosis of the duct, foreign bodies, pressure, or other forms of mechanical obstruction.   Examples are kidney cysts and mucous gland cysts.   (2) **Parasitic cysts,** which are formed as a result of parasites imbedding themselves in the tissues.   Tapeworm cysts in the muscles and those due to worms lodging in the testicles are examples.   (3) **Dermoid cysts,** which are caused by wandering cells from the skin or mucous membranes during embryonic life.   An example is the tooth follicle cyst found at the base of the ears in horses.   In these cases probing will reveal one or more teeth, which should be removed by a surgical operation.

PARALYSIS

Paralysis is loss of nervous control over the muscles that govern the various body activities.   It is general when all the body muscles are affected; local when the muscles of a certain part are affected.   The cause is interference with the motor nerve supply.   It may be due to injury to the nerves or to the centers controlling the nerves.   When the loss of control is slight or incomplete, the term *paresis* is used to designate the condition.

WOUNDS AND WOUND INFECTIONS

SYMPTOMS, TREATMENT, AND HEALING OF WOUNDS

A *wound* is any break in the continuity of the skin or mucous membrane. More or less destruction of tissue always occurs as the result of a wound.

The **kinds of wounds** usually recognized are: (1) *incised wounds*, with clean-cut margins; (2) *lacerated wounds*, with flaplike tears; (3) *punctured wounds*, with small, round openings; (4) *contused wounds*, with the tissues bruised from contact with a blunt instrument. The size of a wound is no guide to the prognosis, which should depend in large measure on the situation of the wound and the nature of the injured vessels. Minor wounds are just as likely to lead to complications as are extensive ones.

The **symptoms of wounds** are hemorrhage, pain, gaping, and disturbed function.

Hemorrhage is the escape of blood from the vessels in which it is normally contained. It varies according to the size and kind of the wounded blood-vessel, but is most pronounced in incised wounds. When an artery is injured, the blood is bright red in color and spurts out with each heart-beat. An injured vein allows blood of dark-red color to escape—it flows steadily from the wound and upon exposure to the air turns lighter red. Capillary hemorrhage is intermediate in color and oozes. If hemorrhage is into the body cavities, the blood is rapidly and entirely absorbed. From the tissues absorption is slower, and a "black-and-blue spot" or "blood blister" (hematoma) remains for some time to mark the location. Where over one-third of the total volume of blood is lost, the pressure falls and death may follow. After excessive loss of blood the visible mucous membranes become very pale, the animal gets dizzy, loses consciousness, and goes into convulsions. There is a rapid re-establishment in the quantity of the blood following hemorrhage by absorption of fluids from the tissues and intestines. The solid constituents

240

regain their normal numbers more slowly, for they must be manufactured by the various blood-forming organs.

Pain results from injury to the sensory nerves.   The blunter the cutting instrument, and the slower the separation of the tissues, the greater is the pain.   There is much variation in the ability of different animals to bear pain.

Gaping refers to the separation of the margins of the wound.   A transverse wound always shows this symptom more than a wound in the same direction with the fibers of the injured tissues. Gaping is most pronounced in incised wounds.

Disturbed function is evidenced by such symptoms as lameness, impaired mastication, or inability to swallow.

In the **treatment of wounds** the first thought should be the arrest of hemorrhage, then the removal of foreign bodies, and finally the dressing of the wound.

Arrest of hemorrhage is normally brought about by the contraction and retraction of the ends of the severed vessel's walls and the formation of a blood-clot.   When these natural processes are not sufficient, artificial means to control the loss of blood must be employed.   These consist of the following:

Ligation or tying the bleeding vessel.   For this purpose silk or catgut is used.   Artery forceps are useful to pick up the injured vessel so that the ligature may be applied.

Compression by the application of a hard pad or bandage. Even pressure with the finger over a cut vessel gives temporary relief.   An elastic bandage, towel, or other form of tourniquet tied on the side nearest the heart is a temporary method of restraining bleeding.

Torsion or twisting of the vessel on its long axis retards the flow of blood so that a clot forms.

Heat, in the form of a red-hot iron, is useful where smaller vessels are wounded.   It also assists in destroying infectious material which may have gained entrance to the wound, and hastens the formation of a scab to seal the wound against subsequent infection.

Chemical agents, like iron chlorid and oil of turpentine, have been used with more or less success, but are only serviceable when the hemorrhage is slight.

Removal of foreign bodies should be the second step in wound treatment.   Pieces of wood, wire, glass, slivers of bone, and clots

16

of blood may be found in wounds.   Unless all foreign and dead matter is removed, it will be impossible to get permanent healing.

Dressing wounds includes their cleansing, suturing, and bandaging.   These will now be explained.

Cleansing is best carried out by applying a fluid that has some antiseptic properties.   The fluid may be applied with a syringe or pledgets of cotton.   Among the many fluids used in dressing wounds, carbolic acid solution is most popular.   It is employed in 3 per cent. strength made with boiled water.

An antiseptic called "Dakin's fluid" after its discoverer and consisting of sodium hypochlorite has been used very successfully in the great war for wound treatment.   It is injected or irrigated into the wounds, which are lightly packed with gauze saturated in the solution.   So effective is this remedy that a badly infected wound will usually be practically sterilized in three or four days.   Amputation of limbs with compound fractures has been found unnecessary in most cases when this method has been used.   Sodium hypochlorite has the power quickly to separate and dissolve necrotic material in a wound.   The surgeon has in this antiseptic a wonderfully satisfactory aid.   Its main disadvantage is that it rapidly dissolves the wound cement.

Tincture of iodin makes a very good wound cleanser.   It is the only substance that is capable of killing bacteria in the tissues without affecting more than slightly the growth of the tissue cells.

Alcohol is of no practical value unless in 95 per cent. strength. A 10 per cent. solution of alcohol has no harmful effect either on bacteria or on tissue cell growth.

Hydrogen peroxid is much less valuable than is popularly believed.   In the presence of organic matter it rapidly reduces and loses its antiseptic property.   It is a powerful deodorant, but should not be relied upon as an antiseptic.   Compared with carbolic acid it is about $\frac{1}{60,000}$ as efficient.   When applied to a wound with much pus accumulation it acts mainly as a mechanical agent to bring the tissue débris from the depths.

By suturing is meant the sewing together of the wound edges. It is necessary where there is much gaping.   For this purpose heavy silk is used when it is available.   In an emergency heavy linen thread, or common white twine and a darning needle may be used.   Whatever material is employed must be boiled or

soaked in a strong disinfectant solution to render it sterile.   The stitches are to be taken a considerable distance from the margins of the wound in order to prevent tearing.   Do not draw the stitches too tightly or the swelling, which always follows, will cause them to tear out.   The surgeon's knot is employed to tie the ends together.   Stitching is contraindicated where much pus is apt to form.

Bandages to protect against infection and injury are helpful in operation wounds and wounds near the feet where filth is apt to enter.   Many wounds, especially barbed-wire cuts, heal better without bandaging.   Bandages and other dressings must be changed as soon as they become saturated with the wound secretions.   At this time the wound is cleansed with an antiseptic solution.   The surface of the wound should be sopped instead of rubbed to avoid irritation and injury to the newly formed granulation tissue.

A dusting-powder, composed of iodoform and boric acid in equal parts, or iodoform 1 part, boric acid 4 parts, and tannic acid 1 part may be sifted on to the wound to check secretions and promote healing.   If pus has a tendency to collect in pockets, it should be swabbed out daily or the pockets opened by an incision so as to allow free drainage, promote healing, and prevent absorption of the poisonous substances in the pus.   For animals weakened from loss of blood, the logical treatment is an injection of normal salt solution.   This is introduced intravenously or intraperitoneally and gives immediate relief.   In veterinary practice it is much better than blood transfusion.

Wound healing is the process by which the destroyed tissue is replaced and the normal condition is restored.   The rapidity and completeness of recovery is determined by the form of wound healing which takes place.   The three following forms are easily recognized:

(1) *Healing by primary intention* consists of a direct and rapid union of the margins of the wound without the formation of pus. In order that a wound may heal in this manner it must be fresh and non-infected, have even edges, and have lost but little substance.   Minor cuts and other wounds of man heal by this method if kept free from organismal contamination.   In our domestic animals these conditions are found only in operation wounds, and then only when protection is afforded by bandages.

Within twenty-four hours the edges of the wound adhere with blood, afterward a fluid-like substance, wound cement, performs this function.   The surface of the wound remains dry.   In four to eight days definite union results, and a relatively small scar is the only sign left of the wound.   .   `

(2) *Healing by secondary intention* is characterized by the production of granulation tissue, and is generally accompanied by pus formation as a result of infection from pus-producing organisms.   Old wounds, infected wounds, and wounds with loss of substance heal under this method.   The granulation compensates for the destroyed tissue, and also forms an important protection against the entrance of any infectious material into the blood-stream whence it might be spread to all parts of the body.   It is a good sign when granulations appear in a wound, for there is then no further danger from absorption of poisons.   This function of granulation tissue has been demonstrated by placing pure cultures of anthrax bacilli on a granulating wound of a sheep.   The disease did not develop, even though sheep are very susceptible to anthrax.

(3) *Abnormal wound healing* implies the formation of excessive amounts of granulation tissue, termed "proud flesh" or "grapes," a complication often seen in wounds around the hoof-head.   It occurs when the process of healing is too rapid.   The cause is excessive irritation from mechanical irritants, such as licking and rubbing the part; or chemical antiseptics, such as copper sulphate injudiciously used; or bacteria in great numbers.   Proud-flesh formation must be stopped before the wound will heal properly.

Scars result from the newly formed connective-tissue cells, which contract with age and force the blood out of the parts, leaving the typical white appearance.   A scar contracts for a long time after healing has taken place.   This accounts for the pulling and "stitches" felt in healing and healed wounds.   If the end of a severed nerve becomes caught in the scar-tissue when the wound heals, pain may be felt for years, but is always referable to the normal ending of the nerve.

SPECIAL KINDS OF WOUNDS

Galled shoulders result from improperly fitted collars, too large collars, collars too wide at the top, or an accumulation of dried sweat and dirt on the collar or collar pad.   The first step

in remedying this trouble is the adjustment of the collar to the neck by fitting it snugly.   If this is not successful in preventing further galling, the draft should be raised from the point of the shoulder.   Treatment for galls does not differ from that outlined for other wounds.   Washing the shoulders night and morning with a solution of common salt and water in the proportion of a dessertspoonful to 1 quart is useful to keep the skin clean and toughen it.   The application of zinc oxid ointment is recommended when the animal must be kept at work.   Sometimes a hole cut in the sweat pad, at the place where it comes in contact with the wound, will give relief and hasten healing.   Obstinate cases are often due to deep-seated abscesses and require an operation for a permanent cure.

Sore neck is caused by excessive collar pressure and rubbing. First see that the draft is not too high up, for this has a tendency to pull the collar downward and bring too much pressure on the top of the neck.   Try slackening the hame strap at the top and tightening the one at the bottom.   Treat as advised for galled shoulders or apply white lotion each night.   Sometimes a depression or "pocket" appears in the center of the raw surface on top of the neck; as a result, an accumulation of the wound secretions occurs.   Later necrosis may set in.   If it does, a "sit fast" develops which can only be satisfactorily treated by having the dead tissue removed by the surgeon's knife.

Cracked heels, scratches, or **mud fever** are terms applied to inflammatory changes in the skin which result in transverse cracks in the hollow of the heel.   The condition may be acute or chronic.   It is oftenest seen in the winter and spring, when the feet are apt to be wet much of the time.   Other causes are washing the lower limbs but failing to dry them thoroughly; overfeeding with concentrates; lack of exercise; leaving mud on the legs, especially if it contains irritant substances like salt, lime, or alkali.   It is said that clipping the heels predisposes to scratches. The symptoms are local heat, swelling and tenderness in the skin, roughness to the overlying hair, stiffness, and lameness.   Unless treatment is prompt, the cracks widen, become infected, and pus forms.   The edges of the wounds present a gum-like secretion, which soon dries and leaves a dirty appearing surface.   In applying treatment the aim should be to remove the irritating cause and hasten wound-healing by keeping out infection.   The part

must be thoroughly dried by the use of hot bran or sawdust packs and a light, clean bandage applied.   The animal should be allowed a few days' rest and provided with a laxative ration, to which may be added a tablespoonful of artificial Carlsbad salts three times a day to regulate the bowels.

Grease heel is a very troublesome affection of the skin often associated with peculiar fungus growths, called "grapes."   It may involve any part of the legs covered by the long hair from the knees and hocks down.   Heavily feathered, coarse skinned, sluggish horses are predisposed to grease.   The causes are similar to those of cracked heels, the difference in the symptoms being due to the character of the secondary invading microörganisms. The chief symptoms are a moist, greasy feel to the skin of the region, an offensive discharge, grape-like outgrowths, falling of the hair, and stiffness.   In bad cases the malady extends to the horny frog, which becomes soft and throws out canker-like growths.   When instituting treatment hygienic measures are important, but require medicinal aid to establish a cure.   Internally, $\frac{1}{2}$-ounce doses of Fowler's solution of arsenic night and morning are indicated.   If proud flesh forms it may be burned off with a hot iron.   Treatment suitable for one patient may be entirely ineffective for another, so each case must be handled on its own merits.   A dressing made of 1 ounce of vaseline, 2 drams of zinc oxid, and 20 drops of iodized phenol has been recommended by veterinarians with wide practical experience.

Necrosis, or **gangrene**, is that condition in which a group of tissue cells have died.   It may be either dry or moist depending upon the appearance of the affected part.   The dry form is also known as *mummification*.   When a piece of bone undergoes necrosis it forms a *sequestrum*.   The common causes are pressure from lying on hard floors, too tight harness, strangulated hernia, frost bites, clumps of bacteria, and anything which prevents the blood from circulating freely.   Treatment consists in removal of the dead tissue and the application of disinfectants. Gangrene appearing after an operation is evidence that the surgeon is incompetent or ignorant.

Old wounds may need to have the edges freshened, especially if they are to be brought together by sutures, so that the skin cells may proliferate and healing take place more readily.   Healing can be stimulated in old sores by applying a blister.

Neglected wounds may become fly-blown in the summer. The eggs laid by the flies hatch into maggots which burrow into the tissues and cause much damage. The maggots must be removed at once and the surface of the wound dusted with a dressing powder to keep other flies away.

Ulcers are old wounds with no tendency to heal. They are often called "running sores." A careful examination will usually reveal some foreign irritating material, which must be removed before healing will take place. When they occur over a bone it should be exposed and scraped. Scars are always left when ulcers heal.

Fistulæ are abnormal tube-like passages. When they have but one opening they are termed "blind fistulæ." A true fistula is one that discharges the secretion of an organ. In the horse such a fistula is most common as a result of injury to the duct of one of the salivary glands. The continuous dripping of the saliva often makes healing impossible, and permanent relief can be obtained only by actually destroying the function of the gland with injections of iodin.

Open joints may be defined as external wounds which communicate with joint cavities and allow synovia to escape. They often occur as a result of a puncture wound caused by a fork-tine or similar pointed object. They are dangerous, because infection easily gains entrance to the joint cavity, where absorption of poisons is very rapid. Treatment must be immediate to prevent serious consequences, and had better be left to a veterinarian. If fresh, shave the hair from about the wound, but do not probe it. If infected, the wound ought to be flushed out with a non-irritating antiseptic solution, using care to keep everything absolutely clean. A bandage should be applied, or the skin wound covered with collodion, if no pus organisms have gained entrance. After twenty-four hours remove the bandage and examine for evidence of synovia. If this fluid is present put on another dressing. In case pus with a foul odor forms the prognosis is doubtful.

WOUND INFECTION DISEASES

A number of diseases are directly due to wound infection. Besides those caused by specific microörganisms, like anthrax and

tetanus, there are recognized the following: suppuration, abscess formation, wound fever, septicemia, and pyemia.

Suppuration is a wound infection disease caused by infection with one or more of the pus-producing microörganisms, viz., Staphylococcus pyogenes aureus, Staphylococcus pyogenes albus, Streptococcus pyogenes, and the Bacillus pyocyaneus of blue and green pus. Pus is a fluid of light yellow or green color, somewhat creamy consistency, and having a characteristic odor and sweetish taste. When collected in a test-tube and allowed to stand, it separates into a supernatant liquid containing salts in solution and a sediment containing the solid elements of pus, viz., pus cells, bacteria, and tissue débris. The cells of fresh pus (leukocytes) are alive and capable of movement; those in old pus are usually dead. Pus acts as a mechanical cleanser and brings irritating substances from the depths of wounds. When allowed to remain in the tissues very long it corrodes them, so wounds with much pus should be cleansed frequently.

Abscess formation is one of the most common wound infection diseases. An abscess is the local accumulation of pus in the tissues. There are "hot abscesses" and "cold abscesses." The hot abscess is always very sensitive to pressure and is accompanied by the other symptoms of inflammation—viz., heat, redness, and swelling. Cold abscesses are gradual in development and non-sensitive. The skin is adherent over the surface of abscesses. Advantage is taken of this fact in differentiating between abscesses and other swellings. In the majority of cases the abscess has developed so far by the time it is noticed that attempts to absorb or "scatter" it are futile. However, in the early stages the daily application of tincture or ointment of iodin will be found beneficial. The application of a light blister or a stimulating liniment assists absorption. Usually the best results are obtained by applying a poultice to the "gathering" to bring it to a head quicker than naturally. For this purpose "Denver Mud," antiphlogistin, or a flaxseed poultice, with an antiseptic added to keep down injurious germ growth, is useful. As soon as the abscess softens in the center and the hair falls out it is ripe and ready to be opened. This is done by making a liberal incision to allow free draining of the pus. Boils and carbuncles are abscesses of the skin. Most often the bacteria which cause them gain entrance through hair follicles.

Wound fever includes a rôle of symptoms, among the principal of which are elevated body temperature, loss of appetite, and deranged digestion.   It is caused by the resorption of poisonous substances from the wound secretion.   When the materials absorbed are bacteria or toxins produced by bacteria in the wound, the condition is known as septic or bacterial fever.   In the main, treatment consists in the application of antiseptics directly to the wound.

Septicemia means the presence of bacteria and their poisonous products in the circulating blood.   It is commonly known as "blood-poisoning."   This disease may follow extensive wounds that have been neglected.   As a sequel to decubitis (bed-sores) it complicates cases in which paralysis of the limbs renders standing impossible.

Pyemia is that wound infection disease in which pus organisms are found in the circulating blood.   It leads to secondary multiple abscess formation in the internal organs and generally throughout the body.

METHODS OF RESTRAINT AND COMMON OPERATIONS

RESTRAINT

The object of restraint is to secure the animal in such a manner that it can neither injure itself nor the person handling it. To be most effective, restraining apparatus should inconvenience and pain the animal as little as possible. Kindness and gentleness on the part of man go a long way toward getting the animal's confidence.

TWITCHING

The twitch is the most satisfactory and convenient way to restrain horses and mules in the standing position for common operations. It is made by passing a loop of cord through a hole bored in one end of a round stick (Fig. 62). The loop should be

Fig. 62.—A homemade twitch.

large enough to admit the closed fist. To apply the twitch the operator passes his left hand through the loop of the cord and firmly grasps the upper lip of the horse. With his right hand he twists the stick of the twitch until the lip becomes tightly squeezed by the cord. It acts by squeezing the lip until the pain produced is sufficient to divert the animal's attention. It is inhuman to twist the twitch tighter than is absolutely necessary, besides there is danger of causing paralysis of the lip.

HOPPLING

Hopples are used to tie the feet together for the purpose of securing the animal in the recumbent position for operations.

250

They have the advantage over any other method of restraint in that they can be applied quickly and serve securely to cast the animal.

Knowles' casting harness is simple in construction, besides being cheap, durable, and easy to apply (Fig. 63). It consists of a wide web collar, from which ropes extend backward on each side to the hind pasterns. The free ends of the ropes are used to tie the feet and legs after the animal is thrown. An improvised harness for emergency use to answer the same purpose can be constructed on this plan from a long rope.
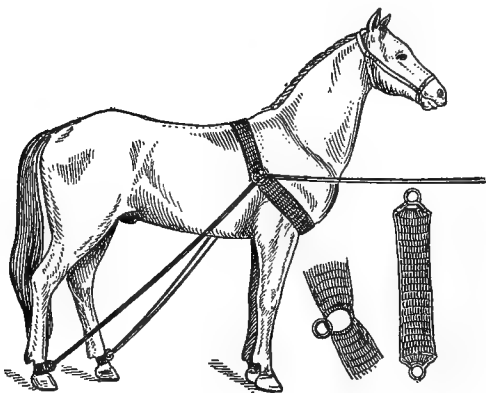
FIG. 63.—Knowles' casting harness.

English hopples are a form of casting apparatus in common use. They consist of four strong leather straps that are buckled to the pasterns. These are all connected with a chain, which can be released by simply withdrawing a small bolt. The disadvantage of these hopples is the danger of breaking the back or a bone in a limb during efforts of the animal to gain freedom. If an assistant holds the head with the nose turned up this accident may be avoided.

ANESTHETIZING

Anesthetics are used to render a part or the whole of the body insensible for the purpose of performing operations with greater dispatch and more safety to both the operator and the patient.

Local anesthetics are employed when the part operated upon is limited in area.   General anesthetics produce a loss of consciousness, sensation, and motion.   The muscles relax and the patient lies motionless when anesthesia is complete.   It should be understood that accidents and dangers attend general anesthesia of the horse.   Chloroform and ether are the chief anesthetics used. Either of these may be given while the horse is standing, by means of a "mask" or "inhaler" that slips over the muzzle and straps around the face.   More often the animal is thrown, one nostril is plugged with cotton, and he is made to inhale the fumes of the anesthetic through gauze stretched across the other nostril. From 3 to 6 ounces of chloroform, given over a period of some twenty minutes, are necessary to place the horse fully under its influence.   Chloral hydrate has many advantages as a narcotizing agent.   It is given in aqueous solution either intravenously or by the mouth.   The dose varies from 20 to 70 grams.   Cocain is the most popular agent for producing local insensibility to pain. It is injected hypodermatically over the nerves of the part to be operated upon.   As a means of finding the exact seat of lameness it is especially valuable.

SLINGING

Slings are useful to support the animal in the standing position when he is unable to stand without assistance.   If the horse refuses to assist himself and hangs in the slings they should not be used.

There are a number of different types of slings on the market. The older makes have a wide canvas girth, which passes under the body and presses on both the sternum and the abdomen.   They are objectionable for the reason that too much pressure is brought to bear on the abdomen when the horse throws his weight into the slings.   With pregnant mares this is a decided disadvantage, as it may result in abortion.   In any case, the abdominal viscera are pushed forward and press on the diaphragm, which, in turn, compresses the lungs and interferes with respiration.

The newest type of sling is so constructed that the weight is borne by a relatively narrow girth and breast-piece, which press only on the sternum and pectoral muscles, and has a breeching in which the horse may rest the hind quarters with safety and comfort.   All the parts of a good sling should be adjustable by means

of straps. A self-locking chain pulley is the most satisfactory method of regulating the height. It should be suspended from an overhead beam or ring. Such an arrangement is so easy to operate that a boy can raise a heavy animal without assistance.

CASTRATING

Castration is the unsexing of the male and consists in the removal of both testicles. Its objects are to prevent reproduction, to increase the fattening propensity, and to make the animal more docile and easier to handle. Food-producing animals produce a better quality of meat when castrated. The operation is not attended with danger, if performed while the animal is young, unless there is a hernia of the bowel into the inguinal canal or scrotum, or the usual precautions to exclude wound infection are neglected. Perhaps the spring is the best time of year for castration, as the flies are less prevalent and the weather is suitable.

The testicles of the colt usually descend into the scrotum shortly after birth. Too early removal interferes with the development of masculine characteristics. It is the custom to postpone castration until the colt is at least one year old. Colts are less difficult to handle on account of their size, and are more resistant to wound infections than mature stallions. The operation may be performed either in the standing or recumbent position. Fractious animals had better be thrown and securely tied to prevent injuring themselves or the operator. Further advantages are that the field of operation can be more thoroughly cleansed and subsequent wound infection prevented.

Calves, lambs, and pigs should be castrated while they are young; the best time is between six to eight weeks of age, as there is less danger of checking growth.

The emasculator and ecraseur are the two instruments given preference in America for castrating. Undoubtedly the improved emasculator is used more generally. It has the advantage of simplicity in construction, so is easy to sterilize and use. It is designed to crush the tissues before it cuts them and thus prevents serious hemorrhage. The ecraseur has a chain loop, which is gradually screwed down over the spermatic vessels by turning the handle.

The clam is an instrument used for compressing the cord. It is composed of two pieces of flat steel or wood, which have serrated edges and are united by a joint. Up-to-date operators do not favor the use of the clam, because there is greater danger that pus-producing organisms will be retained.

In order to insure success in castrating animals there must be provided:

(1) Cleanliness to reduce the chances of infection. This includes a careful washing and disinfection of the field of operation, of the hands, and of the instruments.

(2) Good drainage to prevent pus accumulations in the wound. To insure this, a large, free opening should be made in the skin and other coverings of the testicle.

(3) Exercise to work the pus out of the wound and keep the swelling down. It is best given by an hour's walk at the halter for the first few days after the operation, then brisk trots. Animals turned out to pasture immediately following the operation recover quicker than those confined to the stable, where opportunity to infect the castration wound is greater and daily exercise is limited.

Castration of animals exposed to or infected with disease had best be postponed. The operation should not be performed at the time other surgical operations are executed.

Scirrhus cord results if the spermatic cord is left too long at the time of castration. This is a condition in which infection occurs and the stump of the cord becomes inflamed, hardened, and discharges pus more or less continuously. It is generally very troublesome, for adhesions take place and interfere with the normal movement of the limbs. The only permanent relief is complete removal of the diseased tissues.

Ridglings are male animals in which one or both of the testicles fail to descend into the scrotum, hence they are termed *cryptorchids*. They exhibit all the traits of entire males but are not satisfactory sires. For these reasons they should be castrated. The operation is more dangerous than ordinary castration, as it usually requires an artificial opening into the abdominal cavity. This exposes the peritoneum to infection and may result in peritonitis. If this disease does develop, death is likely to follow at once. Every precaution must, therefore, be taken to maintain surgical cleanliness when operating upon a ridgling.

The flesh of ridgling and entire male hogs immediately after killing has a decidedly unpleasant odor which reminds one of the odor emitted by living boars. This odor is designated urine-like or sexual. Although it gradually diminishes when the carcass is cooled, it again becomes noticeable as soon as the meat is warmed in the process of cooking. The characteristic odor is also accompanied by a similar bad taste. Meat of such animals is not fit for food.

SPAYING

Spaying is performed to remove the ovaries (ovariotomy). It is attended with the same danger that accompanies ridgling castration. Mares are spayed to alleviate vices caused by diseases of the ovaries. The animal should be carefully prepared for the operation by having been kept on a scant diet for at least twenty-four hours beforehand. There are many dangers incident to the operation of ovariotomy, so none but a skilled veterinary operator should attempt it. It may be said that an incision is made in the wall of the vagina through which the ovaries are removed. Cows and heifers are spayed through the flank for the purpose of making them fatten more readily and produce a better quality of beef. In the past sows were spayed, but it is not considered necessary or profitable now.

CATHETERIZATION

The catheter is a tube-like instrument used to remove the urine from the bladder. Catheterization is the operation of passing the catheter. Resort is had to this method of relief when the animal is unable to urinate. In the stallion and gelding catheterization is more difficult than in the mare, whose urethra is shorter and of greater diameter. Some trouble may be experienced when the point of the catheter arrives at the bend of the male urethra where it curves over the ischial arch. By working with the forefinger, and at the same time gently but firmly pushing the catheter upward the difficulty may be overcome. The bladder of the mare may be emptied by pressing upon it with the hand inserted in the rectum. The male bladder may also be emptied in the same way but not so easily.

BLISTERING

Blistering is an operation often resorted to in the treatment of animals. It is a means of bringing more blood to a part and thus hastening nature's reparative processes. Blisters are composed of such irritating substances as cantharides (Spanish fly) and iodid of mercury. These are mixed with some fatty substance such as lard or vaseline to form an ointment. Before applying a blister the hair should be closely clipped and the scurf brushed out of the skin. The agent must be rubbed into the pores of the skin with the palm of the hand to produce the desired effect. If the application has proved effectual, there will be vesicles or blisters upon the part after twenty-four hours, with some swelling of surrounding parts. On the third day it is usual to bathe the part with warm water and soap, thoroughly dry it, and then apply sweet oil or vaseline to prevent cracking of the skin.

FIRING

Firing is the application of a hot iron or the thermocautery to a part. It has for its object the conversion of a chronic into an acute inflammation. When properly used it hastens nature's processes by bringing more blood to the part and makes the animal suitable for work sooner than would otherwise be the case. It is not effective as an agent to reduce the size of bony growths. A more detailed account of the kinds, uses, and manner of applying this method of cautery is given in the section on Treatment for Bone Diseases. For cases of sprained tendons and ligaments after acute inflammatory symptoms have subsided, it is very useful to strengthen the weakened tissues. Less use is made of the actual cautery than in former times because it is recognized that many of the attributed benefits are the result of the enforced rest that must follow firing.

KILLING

Killing a horse is a somewhat unpleasant duty which every horse-owner may be called upon at any time to perform. The most effective way is to shoot the animal. The place where the bullet should enter is accurately located at the point of intersec-

tion of two imaginary lines drawn from the bases of the ears to the opposite eyes; with cattle the point where lines intersect when drawn between the opposite eyes and horns.   Even when shot with a .22 caliber firearm the animal will drop dead, without a struggle, on the spot upon which he has been standing.

REDUCING RUPTURE

Rupture or hernia is a condition in which a loop of the bowel has escaped from the abdominal cavity and lies superficially beneath the unbroken skin.   The resulting enlargement yields to pressure, and may be reduced by working the contents through the hernial ring.   Rupture occurs most frequently at the navel, but is not rare in the scrotum and at points along the abdominal wall where there is a weak spot.   A kick or a blow is a common cause of hernia after birth.   At the navel it often results from a weakness left when the navel cord became detached, and is known as *umbilical hernia.*   Ruptures are not uncommon in colts.   They frequently outgrow the trouble, so it is wise to defer surgical interference until they are at least one year old, unless there is danger of strangulation by pressure.   When an operation is deemed necessary a skilled veterinarian should be summoned, as adhesions may have occurred that must be broken down. When properly performed, the operation will result in a permanent cure in the great majority of cases.

DOCKING

Draft horses are sometimes subjected to this inhuman operation, which is rapidly falling into disrepute and is now unlawful in most states.   Thirty years ago fashion demanded docking for heavy harness horses in order to make them appear "smart." In cases where tumors occur on the tail, or the animal switches and kicks a great deal, it may be removed either by the surgeon's knife or by the docking shears designed especially for this purpose. Restraint is accomplished by the twitch and the side-line.   All lambs should be docked.   The operation is not very painful and no hemorrhage occurs when a special docking iron heated to a cherry-red heat, or the castrating emasculator is used.

17

NICKING

Under this term may be mentioned the operations for correcting curvature of the tail, and the prevention of the gripping of the reins by the tail. The first operation is the simpler, and consists in simply cutting across the levator or extensor muscles of the side toward which the tail is curved. It is performed subcutaneously under the control of the twitch and side-line. If the operation is successful, the tail will be carried in a normal manner after the wound heals. The operation to prevent gripping the reins is more extensive, and usually requires that the animal be thrown. It consists in dissecting out and removing about 5 inches of the depressor muscles on each side of the inferior surface of the tail.

UNNERVING

Unnerving is performed to relieve pain in a part, to prevent lameness in a limb, or to stop motion, as in the "cribbing" operation. The operation is technically termed *neurotomy*, and consists in severing or actually removing a portion of a sensory nerve. It should always be performed under either local or general anesthesia for it is painful.

Neurotomy should be the last resort for the relief of lameness. When the part is deprived of sensation there is always danger of breakdown in the limbs; besides, if an injury occurs, the animal is not aware of it and serious results follow which may jeopardize life.

The commonly performed neurotomies are digital neurotomy, which has for its object the relief of navicular lameness in cases where plantar neurotomy is not deemed necessary or advisable; plantar neurotomy, for the relief of navicular or ringbone lameness, or other non-infectious, painful conditions below the fetlock; median neurotomy, to relieve lameness due to disease of the fore limb, so located that it cannot be overcome by plantar neurotomy; sciatic and anterior tibial neurotomies, for the destruction of sensation in the hock and parts distal thereto to relieve otherwise incurable spavin lameness and diseases of the tendons.

TENOTOMY

The operation of tenotomy is the dividing of a tendon. It is performed to lengthen a contracted tendon. It is valuable

only in young horses, because the patient must be confined for six or eight weeks after the operation.   Tenotomy is the only method of treating severe "knuckling" due to contraction of the tendons.   As a means of relieving stringhalt, the results, although not 100 per cent. perfect, justify the operation.

TRACHEOTOMY

Tracheotomy is an operation to provide a direct entrance for air into the trachea.   It is performed for the following purposes:

To avert suffocation threatened by swellings or other obstructions in the upper air-passages; to restore to usefulness animals that have difficulty in breathing produced by stenosis of the upper air-passages; to remove foreign bodies from the trachea.

The operation is best performed on the standing animal with the head extended.   An opening is made into the trachea by means of an incision.   There is then inserted a special trachea tube, with a fine wire-gauze covering to prevent dust particles in the air from passing through.   This tube is to be removed and cleansed daily as long as its use is necessary.

ARTIFICIAL INSEMINATION

The impregnator is used in horse-breeding as a practical and satisfactory means of breeding mares that have been difficult or even impossible to breed by direct service.   As a means of breeding several mares at one service of the stallion, it has extended his use to more mares than would otherwise be possible.   It is attempted only when the mare is in heat.

In Bulletin 93 of the Oklahoma Experiment Station, Dr. L. L. Lewis discusses the various forms of instruments employed for artificial insemination and their methods of use.   He emphasizes the necessity of keeping all instruments scrupulously clean.   As the sperm cells are very abundant in the semen, it is not necessary to place a large amount in the womb.   Experiments show that contact with the air seems to have little effect upon the vitality of the sperm cells.   Direct sunlight is injurious to them, and semen left in the sun soon loses its vitality.   The life of the cells is short even when protected, as in normal copulation, so an effort must be made to introduce the semen into the womb without unnecessary exposure or delay.

DEHORNING

When cattle are allowed to run together they should be dehorned. If the operation is delayed until the animals are mature, considerable trouble is incurred in restraining them, besides the bleeding which follows may be serious. To avoid those difficulties, the calf should be dehorned when from five to seven days old by the simple, humane method described below.

At this age a small elevation or "button" can be felt on each side of the head. The hair should be clipped from an area about the size of a nickel around the button. The denuded area is then moistened with a little water and the projection rubbed with a stick of caustic potash until it becomes white and the skin gets very thin.

Care must be taken to wrap the end of the caustic stick with cloth or paper to prevent the chemical from burning the operator's fingers. A little vaseline smeared around the clipped area will protect the surrounding skin from the destructive action of the caustic.

When the operation is deferred until the little horns have developed sufficiently to show a "cap" of true horn, it has been found best to remove the cap with a knife before the caustic is applied, otherwise "scurs" or "stubs" are liable to appear after the animal grows older. If these directions are closely followed success is assured, and the set back which usually results from late dehorning will be avoided.

Mature cattle may be dehorned at any time except when flies are numerous. The animals must be confined for the operation, which is performed with a saw or special dehorning instrument. Precautions must be used to prevent serious hemorrhage by tying absorbent cotton about the horn stubs of all animals which bleed freely, or by drawing a small cord tightly around the horn close to the head. Persistent hemorrhage after dehorning may be controlled by the application of an iron poker, heated to a cherry-red heat, to the spurting vessels. When pus forms the wound should be cleaned with 2 per cent. solution of potassium permanganate and then packed with oakum or surgeons' cotton which has been soaked in this solution.

UNSOUNDNESSES, BLEMISHES, AND VICES

COMMON UNSOUNDNESSES

An unsoundness is any affection which diminishes the usefulness of the animal either temporarily or permanently. The three classes of unsoundnesses usually recognized in horses are:

Acquired unsoundnesses, which appear after the animal is born.

Hereditary unsoundnesses, which are transmitted from parent to offspring.

Breeding unsoundnesses, which prevent a stallion from impregnating the mare, or the mare from conceiving and delivering a living, normal foal.

When offered for public sale it is customary to classify horses as sound, serviceably sound, and unsound. *Sound horses* are warranted to be perfectly normal, although few can be found that do not have some trivial defect or other. *Serviceably sound horses* have at least one unsoundness but it is warranted not to interfere with their utility. Great differences of opinion exist as to what is meant by serviceable soundness on account of the different standards of the examiner. *Unsound horses* are diseased to such an extent that they are unable to render the service expected of normal animals.

Stallion laws exist in many states. The horseman should familiarize himself with those of the various states in which he does business. As Wisconsin was the first state to enact such a law, that part of the text of the Wisconsin law regarding unsoundnesses reads as follows:

"The presence of any one of the following named diseases shall disqualify a stallion or jack for public service: cataract; amaurosis (glass eye); periodic ophthalmia (moon blindness); laryngeal hemiplegia (roaring or whistling); pulmonary emphysema (heaves, broken wind); chorea (St. Vitus' dance, crampiness,

261

shivering, string halt); bone spavin; ringbone; sidebone; navicular
disease; bog spavin; curb, with curby formation of hock; glanders;
farcy; maladie du coit; urethral gleet; mange; melanosis; and
the department of horse breeding is hereby authorized to refuse
its certificate of enrollment to any stallion or jack affected with
any one of the diseases hereby specified and to revoke the pre-
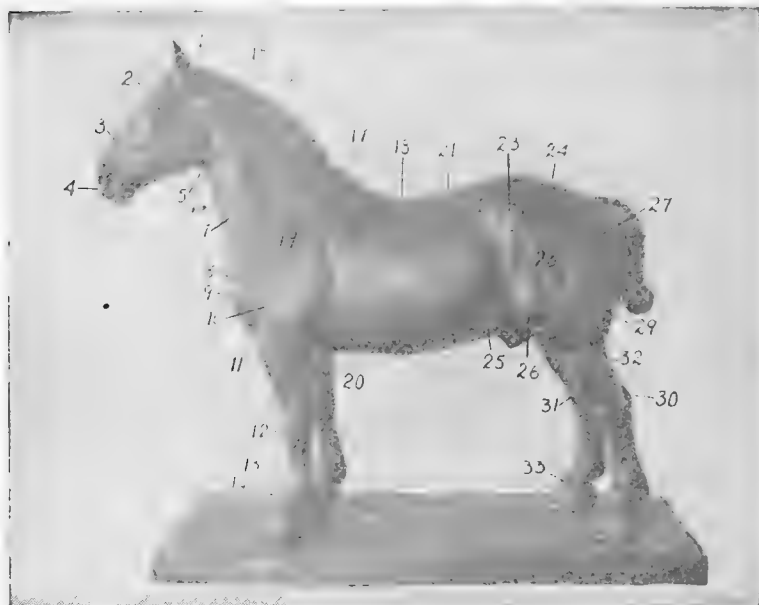
FIG. 64.—Model showing the location and names of the various "points"
of the horse: 1, Poll; 2, forehead; 3, face; 4, muzzle; 5, throat-latch; 6, windpipe;
7, jugular groove; 8, point of shoulder; 9, chest; 10, arm; 11, forearm; 12, knee;
13, fetlock; 14, pastern; 15, neck; 16, crest; 17, withers; 18, back; 19, shoulder;
20, elbow; 21, loin; 22, coupling; 23, hip; 24, croup; 25, flank; 26, stifle; 27,
hip-joint; 28, thigh; 29, quarter; 30, point of hock; 31, hock-joint; 32, gaskin or
lower thigh; 33, coronet.   (Model designed by Geo. F. Morris.)

viously issued enrollment certificate of any stallion or jack
found upon investigation by the department to be so affected."

The "**points**" are external landmarks used in describing and
locating the various parts of the animal.   The principal ones
are clearly shown in Fig. 64.

POLL-EVIL

Poll-evil is a swelling which forms on the top of the neck immediately behind the ears. At first it is hot and painful, later the acute symptoms of inflammation subside. The swelling may be on one or both sides and usually contains pus, or a straw-colored fluid, and involves the large mucous bursa situated
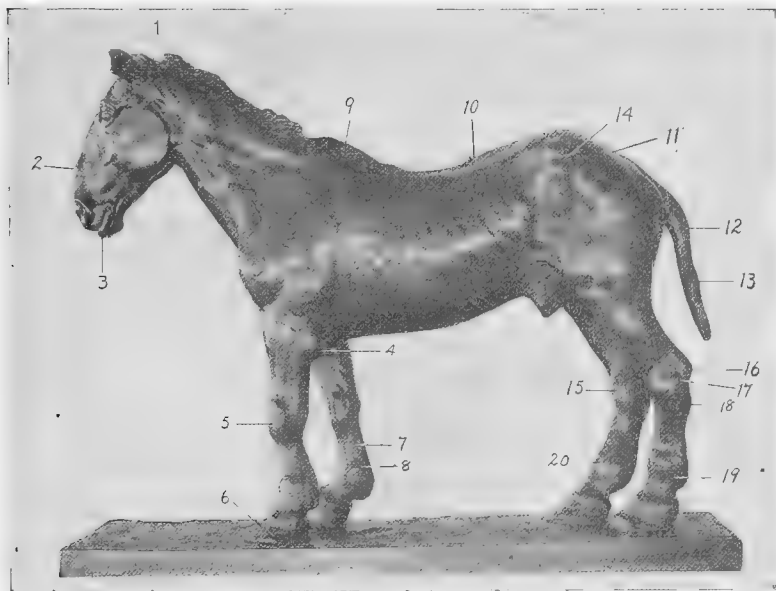
Fig. 65.—Model showing the location of various unsoundnesses and blemishes: 1, Poll-evil; 2, roman nose; 3, pendulous lip; 4, shoe boil; 5, enlarged knee; 6, founder; 7, splint; 8, windgall; 9, fistulous withers; 10, sway back; 11, droop rump; 12, rattail; 13, crooked tail; 14, broken hip; 15, bog spavin; 16, capped hock; 17, thoroughpin; 18, curb; 19, cocked ankle; 20, enlarged fetlock. (Model designed by Geo. F. Morris.)

over the first vertebra. A bruise or other injury is the most frequent cause of poll-evil. External applications of liniments and poultices fail to remedy the condition. Lancing the swelling on each side does not answer, for it is impossible to get complete drainage. Consequently, it will be necessary to have the surgeon incise the enlargement lengthwise and carry the cut over the

prominence of the poll and down on to the forehead to insure permanent relief. Injections of a specially prepared bacterin have proved helpful in hastening recovery.

FISTULOUS WITHERS

Fistula of the withers is a disease similar to poll-evil, but is located at the withers. It is commonly called "thistlelow." Bruises have been thought to be the cause in many cases. In view of the fact that pus is often present, even when there is no evidence of a previous skin wound, it seems reasonable to believe that the pus organisms must have been brought by the blood. Unless the pus is evacuated it may burrow between the muscles and break out on the shoulder. These fistulæ may be very slow in forming. A deep-seated abscess cavity of many months' standing with no external signs of its presence has been found in a horse in the dissecting laboratory. The chief symptom is a hot, painful swelling which appears on one or both sides of the dorsal vertebræ at the withers. A surgical operation to allow the accumulated pus to escape, and to remove thickened tissue and necrosed bone, is the only treatment recommended for permanent relief. Caustic applications to destroy the diseased tissues should be used only on the advice of the attending veterinarian. In most cases success follows proper surgical treatment, but only after several weeks. If the animal has little value, it will be well carefully to consider the advisability of going to the expense in loss of time and the feed required before he would be fit for return to service.

SHOE BOIL

Shoe boil is a soft, flabby swelling that develops at the point of the elbow, hence the name "capped elbow." Chief among the causes of this disease is pressure from the heel calk of the shoe. As a rule, it results in lameness only when acute inflammation is present, and when its size interferes with movement. At best a shoe boil is unsatisfactory to treat. If discovered while yet small, it may be prevented from further development by daily applications of tincture of iodin and the use of the shoe-boil boot or roll, which is designed to be strapped about the pastern to keep the heel from pressing upon the elbow while the

horse is in the recumbent position.   Large shoe boils are only removable by the knife.   As the skin is thin and tightly stretched at the elbow when the joint is flexed, it is difficult to get the operation wound to heal.   The ligature should be mentioned as a means of removing these enlargements.   It is passed around the neck of the swelling and tightened each day until the circulation is stopped and the whole mass undergoes necrosis and drops off.   Shoe boil is usually considered an unsoundness instead of a blemish.

CAPPED HOCK

Capped hock is a soft enlargement that develops at the point of the hock.   It may be hot and painful, but is usually not inflamed and non-sensitive.   A fluid of a serum-like nature will be found if the enlargement is punctured.   This is, however, seldom a wise procedure, for most cases are amenable to simpler treatment, besides the sac rapidly refills.   Little relief follows the application of a blister.   Painting the enlargement each day with tincture of iodin helps to diminish it.   Some cases fail to absorb, even with skilful attention, and the capped condition remains as an eyesore.   If no lameness is present, it is customary to classify a capped hock as a blemish rather than an unsoundness.   If it does not interfere with the work of the horse, it need not be considered a serious unsoundness.

BOWED TENDONS

The tendons situated behind the cannon bone, in both the front and hind legs, are subjected to severe strains from violent efforts or sudden jerks.   When the injury is pronounced more or less swelling and soreness is present.   The swelling usually extends from the knee down to the fetlock, and occasionally even farther. It is always characterized by heat and is often quite painful.   A lameness develops in proportion with the severity of the injury. The tendons relax and bulge or bow backward.   They may not resume their normal position even after the acute inflammation subsides, in which case the bowed condition remains and is considered a permanent unsoundness.   Treatment consists in the application of blisters.   If these fail to bring results, the parts may be strengthened by the use of the firing iron.

COCKED ANKLE

A horse is said to have a cocked ankle when he "knuckles over" at the fetlock joint. This occurs when the slope of the long pastern is rendered less oblique and the bone assumes a more upright position than normally. Close examination shows inability to extend the joint to the usual degree. It is a deformity caused by structural changes in the tendons and ligaments about the joint from heavy work of all kinds. In young horses it may be the result of inherited weakness in these parts. If the cause of the condition can be found it should be promptly removed. Special shoes with low heels and long toes help in many cases (Fig. 66). Severe cases can be relieved only by dividing the shortened tendons (tenotomy).

Fig. 66.—Cocked ankle. This deformity is also known as "knuckling."

WINDGALLS

Windgalls are soft, non-sensitive, puffy swellings filled with synovial fluid. They appear about the fetlock joint and other parts where tendon sheaths are located. These enlargements vary in size, from a hazelnut to that of a hen's egg, or larger. In old horses they are a sign of hard work. Foals develop windgalls from general weakness, but they disappear without treatment when the animals get older. If no inconvenience is given the horse, little attention is required. They rarely diminish the usefulness of the animal unless they become indurated and converted into fibrous tissue. Little success follows the removal of the fluid from windgalls. Massage and bandaging are helpful in reducing them. It is not wise to apply a blister with the hope of getting absorption of the serous fluid, as experience teaches that no permanent benefit results from such treatment. The presence of windgalls that do not interfere with the horse's movements need be regarded only as blemishes.

CURB

Curb is a swelling, or bulging backward, at the back of the hock, about 6 inches below its point. It is caused by anything

that brings about a thickening in the ligament, tendon, or skin of this region, so as to cause a deviation in the straight line that normally extends from the point of the hock to the fetlock (see Fig. 65). To detect a curb the examiner should view the leg in profile from both sides. A curb is often found in an animal with a tendency toward "sickle hocks" (see Fig. 72). When lameness results from curb use a high-heeled shoe to remove strain from the part. Rubbing the enlargement daily with a flat bone helps to reduce the enlargement. The actual cautery often must be resorted to for removal of the lameness. The presence of a curb must always be regarded seriously.

STRINGHALT

Stringhalt is a spasmodic jerking up of one or both hind legs. It is most evident when the horse is walking, turning, or backing. In the first stages the symptoms are slight, but become more noticeable with age. In marked cases the leg is jerked up high and may strike the belly; the downward move is forceful also. Nothing positive is known about its origin. It may usually be cured or greatly remedied by a surgical operation on the lateral extensor tendon. An incision is made over the tendon on the outside of the leg just below the hock, and about 2 inches of the tendon is removed.

BLINDNESS

Blindness may be total or partial. In some forms of blindness there are no signs of disease whatsoever. When the normally transparent crystalline lens becomes opaque, the affection is termed **cataract.** When a foreign body becomes lodged in the eye, the tears stream over the face and the lining of the lids becomes greatly inflamed. Unless the object is removed promptly, a white spot appears or the entire eye turns white. A simple test for blindness is to place a box about 15 inches high on each side of the driveway. Lead the horse back and forth between them two or three times. Then place a slender pole across the boxes and lead the horse along the same course. If blind he cannot see the pole, so will stumble over it. A blind animal uses its sense of hearing more than normal and turns the head sideways and moves the ears quickly in various directions. These signs are an indi-

cation of blindness. A cheap and most satisfactory eye wash for animals is made by dissolving a level tablespoon of common table salt in two quarts of freshly boiled water. It is easily applied by means of an eye dropper.

DEAFNESS

This is neither a common nor a very serious affliction of animals. A deaf horse is a nuisance from the driver's viewpoint, but is capable of giving good service. There is little that can be done in the way of medical treatment for deafness. When it is caused by pressure from an ear cyst, a surgical operation to evacuate the contents of the cyst would be likely to remedy the condition.

TUMORS

Tumors are new growths which appear at times in various tissues of the body from no apparent cause. They may be either benign and slow in development, or malignant and spread very rapidly. Benign tumors remain localized and are not dangerous unless vital organs are involved. Warts are benign tumors. They occur on the thin parts of the skin. To remove warts pull or twist them off, cut them away with a knife, or burn them with a hot iron. All malignant tumors should be excised completely and early with the surgeon's knife, in order to prevent them from encroaching upon neighboring tissues and spreading to other parts of the body. As a rule, caustic agents are to be employed to destroy tumors only on expert advice, for they tend to cause them to spread and favor their growth.

A common form of malignant tumor, occurring in white and gray horses, is known as melanosarcoma and the condition produced as melanosis. Such a tumor is always black in color and contains a large amount of melanin, the pigment found in the skin.

CANCERS

Cancers are malignant tumors composed of epithelial and connective tissues. They have a tendency to persist and grow down into the surrounding tissues. They are found either on the surface epithelium or in the epithelial cells of glands. The

causes are various and numerous irritating agents. Recent experiments go to show that cancers have an infectious origin and can be transplanted in animals of the same species. Cancers occur most frequently on the head and penis of the horse. A diagnosis is made by sectioning and staining pieces of the tissue, or by applying the Abderhalden test to the blood-serum of the patient. Treatment consists in complete excision, but should be early and every trace of the disease removed. If neglected, cancers spread like a fire and get beyond control. As with fire, however, anything less than complete extinguishment may stir up sparks which may result in increased fury.

COMMON BLEMISHES

A blemish is any abnormal mark in either the skin or under-lying structures. Examples are scars and thickenings. A blemish in itself is not an unsoundness. However, a blemish may be the sign of a previous unsoundness, or one that will appear later. In some cases blemishes are the only noticeable guides to serious unsoundnesses.

Interfering wounds are a good example of blemishes that may result in serious unsoundness unless given proper treatment and the animal shod to prevent further "brushing."

Scars from operations for bad teeth, nasal tumors, and other things are blemishes that are important to note, as they indicate the location of diseases which may cause trouble after apparently being cured.

COMMON VICES

Vices are bad habits which may make the animal dangerous to himself, to associates, or to persons handling him. They are often the result of improper education and ungovernable temper. Vicious animals may transmit their undesirable traits, so are not desirable for breeding purposes. Among the most common vices of horses are the following: kicking, striking with fore feet, switching, balking, biting, backing in harness, shying, running away, halter pulling, weaving, rolling, crowding, pawing, blanket tearing, and line hugging.

Cribbing and windsucking are two forms of the same vice in the practice of which the horse while standing draws air into

his mouth, makes a convulsive effort to swallow it, and then
generally emits a guttural noise. They seem to be due to
irritation and idleness. Some authorities class these habits as
unsoundnesses rather than vices. They are objectionable
especially because the affected horse is a hard keeper and some-
what of a nuisance.

Nymphomania is a disagreeable and dangerous vice of the
female accompanied by an excessive sexual desire. It is a great
source of annoyance to owners and caretakers. The causes
may be diseases of the generative organs, particularly the ovaries.
It is a symptom and not an independent disease. Affected
mares are irritable, ticklish and kick, squeal, strike, show frequent
desire to urinate, switch tail, and may be shy breeders. When
cows are affected they are commonly called "bullers" from con-
stantly trying to ride other cows. The treatment is to remove
the ovaries. This operation is not always successful in correcting
the habit, but usually is if the symptoms occur only when the
mare is in heat.

DEFECTIVE CONFORMATION

Defects in conformation and malformations of various kinds
should be avoided in horses used for breeding purposes. Although
these may not be of a nature to be classed with the unsoundnesses,
they do reduce the value of the animal. Some are inherited,
others are acquired.

Badly formed limbs reduce the efficiency to a greater extent
than any other defect in conformation. To detect these varia-
tions from the normal, the horse must be inspected in the stand-
ing position from the front, the rear, and the sides. The com-
monest defects noticeable when the examiner is stationed either
directly in front or behind the horse are "base-narrow" and
"base-wide" deviations. The first gives too little support upon
the ground, while the latter tends to cause paddling and
interfering.

In the fore limb is seen the "pigeon-toed" position, where the
limbs are straight to the fetlocks, but the pasterns and feet turn
in (Fig. 67). When the toes point obliquely outward there is
formed that awkward defective conformation termed "splay-
foot" (Fig. 68). Viewing the fore limbs in profile, we may find

that the legs from the knees downward are placed too far under the body, and the knees are bent backward; this is termed "calf-knee" (Fig. 69). Backward deviation, where only the cannon bone is affected and the horse stands bent forward at the knees, is called "goat-knee," "buck-knee," "over-in-the-knees," or "knee sprung" (Fig. 70). Foals from birth may be knee-sprung, or even unable to stand at all, as a result of contracture in the
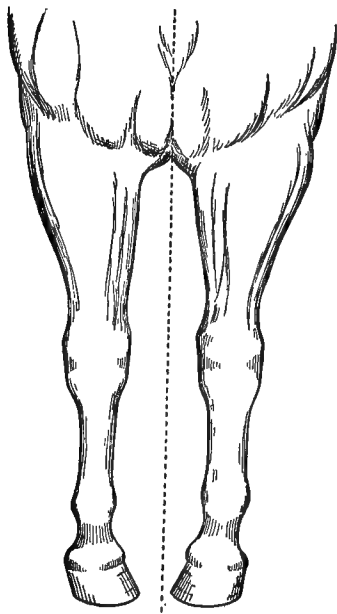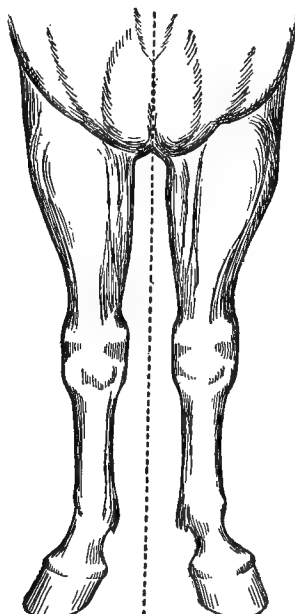
Fig. 67.—Pigeon-toe.   Fig. 68.—Splay-foot.

flexor tendons. Good results have been obtained by applying extension splints to the leg. It may be necessary even to section the two flexor tendons of the knee at the lower end of the forearm to get relief, if the contractions are very marked.

In the hind limbs we may observe the "cow-hocked" position, where the hocks are too close together and turn toward each other, while the feet are widely separated and the toes turn outward (Fig. 71). From the side may be noticed the forward

deviation, termed "sabre-leg" or "sickle-hock," in which the hock-joint is flexed too much, the foot placed too far under the body, and the pastern too sloping (Fig. 72).

Other defects of and abnormalities in conformation undesirable to propagate are a slim head, small jaws and muzzle, narrow chest, loose coupling, roach-back, sway-back, low withers, ewe-neck, droop rump or croup, weak stifles, abnormally long legs, and
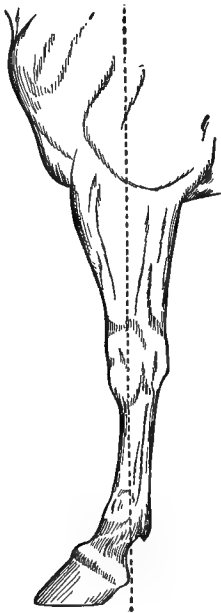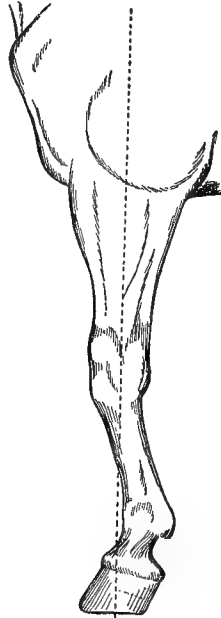
FIG. 69.—Calf-knee.   FIG. 70.—Goat- or buck-knee.

certain defects in the mouth and feet mentioned in other chapters of this book.

EXAMINATION FOR SOUNDNESS .

The **soundness examination** is conducted for the purpose of determining the presence of those unsoundnesses, blemishes, vices, and bad conformations described in preceding pages. In

order to conduct it intelligently, the examiner should have had special instruction.   He will use his senses of sight and touch to determine the parts and organs that are abnormal and the nature of the abnormality.   Only by comparing the suspected part with the normal part of the opposite side can he at times
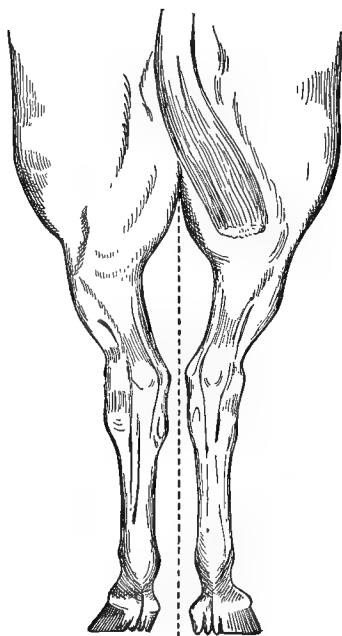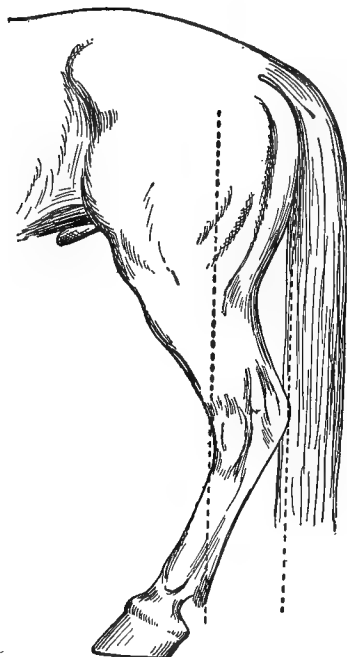
FIG. 71.—Cow-hock.   FIG. 72.—Sickle-hock or sabre-leg.

satisfy himself as to the existence of an unsoundness.   He should place the subject in a good light and inspect it in profile from in front and behind, from the right and left sides, and obliquely forward and backward.

The accompanying outline is designed as a guide in conducting an examination for soundness.

18

Outline for Soundness Examination

Student's Name........................ Horse's Name or Number.................

Date................................. Horse's Color & Markings................

I. *Head and Neck*

Lips: Paralysis................... Wounds.............. Slobbering............

Tongue: Lolling................. Injuries................ Scars ....

Teeth: Age................ Crib-mouth.................. Overshot jaw..........

    Undershot jaw................... Diseased teeth.....................

Nostrils: Nasal discharge......... Ulers.................. Odor to breath........

Eyes: Blindness................. Inflammation.......................

    Discharge................. White spots.........................

Ears: Deafness.................. Discharge............. Fistula...............

Poll: Poll evil......................... Bruises...........................

Neck: Abscesses under jaw............... Abnormal breathing...............

    Rings of trachea broken............ Broken crest.... Collar sores...........

II. *Trunk and Fore Limbs.*

Body: Narrow chest.............. Defective back......... Hernia...............

Withers: Fistula.......................... Saddle galls......................

Shoulders: Collar galls................... "Sweeny"...... Tumors..............

Elbows: Shoe boil...................... Wounds..........................

Knees: Broken knee............. Buck-knee............. Calf-knee.............

    Capped knee.....................

Cannons: Splints................ Sore, thickened, and "bowed" tendons............

Fetlocks: Windgalls.............. Interfering wounds...... "Knuckling"...... ....

Pasterns: Ring-bone............. Scratches.............. Grease heel...........

Coronets: Sidebone............... Quittor................ Calk wounds..........

Hoofs: (on ground) Base wide...... Base narrow............ Pigeon-toe..........

    Splay-foot............... Founder rings.......... Navicular disease.......

    Hollow-wall............... Contracted heels........ Toe or quarter cracks...

Hoofs: (lifted) Thin wall......... Thick wall............. Corns................

    "Dropped" sole........... Contracted frog......... Thrush................

III. *Pelvis and Hind Limbs*

Tail: Docked......... Crooked......... Paralysis........ Tumors...............

Hips: Asymmetric...................... Knocked down..........................

Thigh: Atrophy......................... Scars..............................

Stifles: Dislocated..................... Swellings..........................

Hocks: Capped hock............. Bone spavin........... Bog spavin............

    Thoroughpin............. Curb.................. Stringhalt.............

    Firing marks............. Cow-hock.............. Sickle-hock............

Cannons: Sore, thickened, and "bowed" tendons.............................

Fetlocks: Windgalls.............. Interfering wounds...... Knuckling............

Pasterns: Ring-bone............. Scratches.............. Grease heel............

Coronets: Sidebone............... Quittor............... Calk wounds..........

Hoofs: (on ground) Base wide.............. Base narrow..... Founder rings.........

    Navicular disease................. Hollow-wall.......

    Contracted heels.................. Toe or quarter cracks....

Hoofs: (lifted) Thin wall................. Thick wall.............

    "Dropped" sole........ Contracted frog........... Thrush................

When a blemish is present use $+$; when absent O; for right side R; left L.

DISEASES OF THE FOOT AND SHOEING

LAMENESS

Lameness has been defined as any irregularity in the gait. It is the most serious impediment that may befall a horse because of its frequent occurrence. From a diagnostic point of view it is necessary to distinguish between a "swinging leg lameness," in which the pain emanates from the shoulder or the hip and a "supporting leg lameness," in which the lesion is in the knee, hock, or lower part of the leg.

To detect lameness the examiner should first get a full history of the case. Then he ought to observe the animal at rest. In severe cases he may recognize that pain exists by the horse pointing, frequently raising the affected limb, or placing the affected part in an unnatural position for relief. Next the animal should be trotted past, away from, and toward the observer. The attendant must not take too short a hold on the halter shank, as it would interfere with free movements. The head and hips are to be closely watched at this time, as their movements are a reliable guide in locating the seat of lameness.

Symptoms.—If lame in the right fore leg, for example, the head will "nod" or "bob" when the left or sound foot is planted on the ground, while the head jerks up at the moment the right or lame foot touches the ground.

When lameness exists in both fore legs the action is stiff and stilty, the natural free stride is shortened, and the feet are raised but little from the ground. Almost always the hind legs are picked up higher than normally, the shoulders seem to be stiff, and the head is carried higher than is usual.

Lameness behind may be noted by a dropping of the hip opposite to the one in which soreness exists when the horse is trotted from the observer.

Should there be lameness in both hind legs the stride is shortened and the gait awkward, the fore legs are not advanced in front of the body and are raised higher than usual, and the head is

lowered. It is difficult or impossible to back a horse lame in both hind legs.

Horses lame in both fore and hind legs show a waddling gait behind that may be mistaken for loin or croup lameness. This peculiar motion is simply due to the fact that the hind legs are unduly advanced under the body for their own relief, or that of the front legs.

Shoulder lameness is shown at the time the leg is advanced, for then pain is felt. It is a typical swinging-leg lameness and the toe is dragged. Many horse owners believe that this form of lameness is very common, but it really is quite rare.

In the majority of cases it is not very difficult to detect the limb in which lameness exists, but experience and keen insight are required to locate the exact seat of the trouble. Remember that the largest percentage of lamenesses are located below the knee and hock, and that the foot is involved much oftener than any other part. If the existence of a spavin is suspected, give the horse the "spavin test." Palpation for the exact location of the soreness is a valuable aid in diagnosis, but care should be taken to distinguish between flinching due to nervousness and that due to inflammatory soreness. The presence of one or more of the cardinal symptoms of inflammation are reliable guides in the diagnosis of lameness. By placing the lame leg in its normal position and carefully comparing it with the sound leg for anatomic changes a more accurate diagnosis can be made. In obscure cases resort may be had to cocain injections over the sensory nerves of the suspected part for correct diagnosis.

Unscrupulous dealers practise certain tricks to cover up lameness. Among the common ones are the use of a curb bit and a close hold on the leading rein to keep the head raised and to prevent "nodding." By paring down the sound foot to the "quick" and replacing the shoe so as to make both feet tender, a horse slightly lame may be made to appear normal.

Treatment.—In the treatment of lameness, rest is the principal requirement to restore the horse to perfect soundness or usefulness. The usual means of providing rest are the use of a specially constructed shoe, the application of a blister, trimming the hoof, turning out to pasture. These and other methods of treatment are to be employed only after each case is studied and the exciting cause of lameness has been removed.

QUITTOR

A quittor is a wound of a fistulous nature occurring at the hoof-head.   It is the result of an injury to the structures covered by the horny box.   Nail-pricks, punctures of the sole or frog, bruises, and suppurating corns are common exciting causes.   The irritating substance induces inflammatory changes.   There may be noted the attendant symptoms of inflammation—viz., heat, swelling, redness, and pain.   Lameness is very great, especially in the early stages, as the pressure of the inflammatory exudate on the sensitive nerves of the pododerm is intensified by the fact that little expansion can take place in the hoof.   One or more discharging sinuses which communicate with the infected tissues may be observed in the swelling at the coronet.   Treatment should first be directed toward locating and removing the cause. An examination of the lower surface of the foot may reveal discolored horn.   If found it must be cut away at once to allow the accumulated pus to drain out.   Afterward a 1 : 500 solution of bichlorid of mercury may be injected under pressure into the sinuses.   If the fistula fails to show improvement with this treatment, an operation to remove the necrotic tissue in the depths must be performed.

CORNS

A corn is a bruise of the sensitive tissue, lying directly above that part of the sole between the bar and the wall.   This is the spot most liable to injury, because the horny covering is thinnest and the heel is placed on the ground first, so receives the most concussion.   Corns usually occur only on the inside of the fore foot.   Fast work on hard and rough roads, flat soles, weakened bars, and poor shoeing predispose to corns.   If a simple corn is present there may be but little lameness apparent, unless the horse steps on a stone or other hard substance and bruises the part again.   When the horn of the buttress is examined it will show red discoloration, and pain will be caused if this spot is tapped with the hammer.   It is not advisable to pare this horn away in simple cases.   If pus has formed, a "suppurating corn" occurs.   In this case the shoe should be removed and an outlet for the pus made on the sole surface of the foot, or it will burrow in the direction of the line of least resistance and discharge at the

coronet (quittor). A three-quarter shoe is best for an ordinary non-suppurating corn, as it removes pressure from the inflamed part and relieves lameness.

THRUSH

Thrush results from lack of care of the feet. It is characterized by an abnormal secretion from the cleft of the frog. When the horse is allowed to stand in a filthy place where much moisture is present, the horn becomes soft and loose, its pores open up, and filth enters. The symptoms are the discharge of a dark-colored pus, with a very offensive odor. This may later become profuse and undermine the horn of the frog and cause lameness. There is some heat noticeable in the affected foot and the hoof dries out and gets brittle. Treatment consists in providing a clean, dry stall. All the loose portions of horn should be pared away, so that a dressing may be applied directly to the diseased parts. After thoroughly washing and drying the foot, powdered calomel, or burnt alum may be packed into the crevices.

FOUNDER OR LAMINITIS

This is a painful disease, resulting from congestion of blood between the hoof and the sensitive structures beneath. It is often called "water founder," from its appearance soon after watering a very hot or tired horse. The fore feet are most commonly affected.

Acute founder is the form in which founder first appears. Its causes are overfeeding, or feeding too soon after violent exercise; large draughts of cold water when very warm; rapid cooling of the surface of the body when very sweaty; concussion from excessive driving on hard roads; lack of exercise leading to retarded circulation of blood in the feet; undue pressure on one foot from a painful condition in the opposite foot; circulatory disturbances coincident with parturition or indigestion.

Symptoms.—The disease is ushered in with a chill. There is profuse sweating, rapid breathing, groaning from pain, loss of appetite, and a rise of temperature (103° to 104°F.). The feet are hot, very tender to taps with the hammer, and there is a distinct pulsation in their arteries. The animal exerts every effort to take the weight off the fore feet in which the pain is

intense. When standing, the hind legs are placed well forward under the body to get as much relief as is possible. A foundered horse cannot be made to back; he even moves forward unwillingly.

Treatment.—The patient will be given great relief by cold-water applications to the feet. An easy way to apply moist cold is to saturate gunny sacks with water, or the animal may be made to stand in a foot-bath. The administration of 2 to 4 ounces of saltpeter in the drinking-water three times daily is an old remedy. If the patient is costive he should be given a quart of raw linseed oil. Modern veterinarians rely upon arecoline or aconitine given hypodermically. The grain ration should be materially cut down.

Chronic founder develops from the acute form. The coffin-bone rotates and presses on the upper surface of the sole, which in turn gives under the pressure and a "dropped sole" results.

Symptoms.—The changes mentioned lead to the formation of prominent rings and a concave instead of a straight toe wall. When standing, the horse shifts his weight from one foot to the other; when traveling, the gait is stiff and the steps short and choppy. This peculiarity has led horsemen to believe that the soreness is in the chest, the pectoral muscles of which atrophy, and has given rise to the misnomer "chest founder."

Treatment.—Permanent relief cannot be expected from any line of treatment. However, by keeping the toe rasped down and applying a rubber heel pad or bar shoe a badly affected animal may be kept from getting severely lame, and should give good service on soft roads or ground. Hoof-packings and dressings to supply and conserve the moisture of the foot often afford material help. Point firing around the coronet has not given entire satisfaction, although sometimes used.

SIDEBONE

A sidebone occurs when one of the lateral cartilages attached to the wing of the third phalanx or coffin-bone ossifies (Fig. 74). There are various causes of which a hereditary predisposition to lime salt deposition in cartilaginous tissue appears to be the most common. Horses with flat feet and weak quarters are also pre-

disposed to this disease. It is quite as certain that injuries from treads and similar wounds also set up an inflammation about these structures that may later result in sidebone formation. Lameness may or may not be present. In the later stages of the disease the only symptom is the hard, unelastic prominence just above the coronary band. It may be either unilateral or bilateral and occur on any foot, but is more frequent in the front feet than the hind. In many cases only the lower portion of the cartilage undergoes ossification, the rest retaining its normal elasticity, in which case the affection cannot be readily diagnosed. Blistering and firing are remedies for sidebone that have been employed successfully when aided by shoes with heel and toe calks. The most satisfactory treatment is to take the horse off city pavements and put him at work on soft ground. As a last resort, after other means have failed, unnerving may be employed. Sidebones are properly classed with the unsoundnesses, although they do not interfere with the serviceability of draft horses after lameness ceases. Unlike spavin and some other kinds of lameness, horses do not "warm out" of sidebone lameness.

TOE AND QUARTER CRACKS

Sand crack is another term for these diseases. They are splits in the horn of the wall, the position determining the exact name applicable. The causes are lack of moisture in the hoofs; heavy shoes; nailing the shoe too close to the quarters; separation of the horn from the pododerm. The crack first appears at the coronary band, from where it gradually extends downward either by growth or by splitting the horn. Lameness is caused if the fissure is deep. The first step in treatment consists in removing the shoe and softening the horn by poultices, or by standing in water for a few days. If the sensitive tissues at the coronet can be made to secrete horn of a resistant nature, the crack will disappear in time at the lower border of the wall. To aid in this, a piece of the bearing surface in contact with the shoe about 2 inches long should be cut away to prevent pressure. Shoeing with a bar-shoe is helpful. The edges of the crack may be drawn together with a nail. It takes about one year for a sand crack to grow down. The disease is an unsoundness.

CANKER

Canker results from infection of the pododerm or foot-skin. It is a disease with a slow course, during which a gradual undermining of the horn of the sole and frog takes place. Unless relief is given these structures eventually loosen. Treatment is purely local, and consists in providing dry quarters, removal of all involved tissues, applying antiseptics, and in protecting the exposed sensitive parts from external influences. Most cases of canker require several weeks and often months of careful treatment for a cure.

CONTRACTED HEELS

Contracted heels is a narrowing or "tied-in" condition most often seen in the front feet. Lack of exercise, too little moisture, thrush, or navicular disease may produce contraction. It is, therefore, a symptom of some other affection rather than a disease itself. Remedial measures are given in connection with these other diseases.

NAVICULAR DISEASE

Navicular disease is a chronic inflammation of one or more of the following structures: the navicular bone, the navicular joint, the navicular bursa, the perforans tendon. When the disease first starts it is usually confined to the bone itself; later the articular cartilage becomes roughened. At this stage pain is pronounced with each and every movement of the joint. Many observations show that navicular disease occurs almost exclusively in harness horses.

Causes.—The exact cause is often impossible to locate. There seems to be a particular tendency for it to appear in animals subject to the so-called spavin group of lamenesses. Whether or not this is an inherited tendency remains to be definitely proved.

Symptoms.—At first the symptoms are hardly noticeable. Quite without warning the horse may limp, but after a few steps recovers. When resting, the foot is advanced or "pointed" and the toe is placed on the ground. The fetlock is flexed to take pressure off the navicular apparatus. Later intermittent lameness occurs. In more advanced cases of the disease the

patient becomes severely lame for a week or more.   This may
continue or disappear, only to recur after weeks or even months.
Finally, lameness is constantly present and is aggravated with
use.   The heels contract, the hoof gets hard and dry, the frog
atrophies, the toe of the shoe wears away more rapidly than
normally as it strikes the ground first, the horse stumbles, par-
ticularly when going up hill, and the gait is stiff.   One writer
summarizes the symptoms as follows: "Unless the case is bad
the horse 'points,' raises his heel, and rounds his fetlock joint
when standing.   He walks sound, but when trotted goes 'short,'
'daisy cuts,' and 'digs his toes into the ground.'"

Treatment.—From what has been said about the pathology
of navicular disease it is clear that few cases recover.   Mechan-
ical means to relieve the animal and render him serviceable are
the most sensible forms of treatment.   A plane shoe, without a
bar or toe-calk, is best.   If calks are required, two heel calks
and two toe calks should be used.   In cases of persistent lameness
unnerving may be performed to destroy sensation in the foot.

SHOEING

Shoeing must be considered a necessary evil, because it gives
an artificial base of support and interferes more or less with the
physiologic movements of the foot.   When properly applied,
iron or steel shoes afford protection and render the horse more
serviceable for road work.   The objects of shoeing are: (1) To
protect the hoof from excessive wear.   (2) To prevent slipping
and falling during winter.   (3) To correct faulty positions of
limbs that horses may render good service and increase their
speed.   (4) To cure or improve diseased or defective hoofs and
feet.

In shoeing it is best to follow a definite plan of procedure.
This includes—(1) An examination of the horse at rest, and then
in motion, to detect irregularities in the foot's axis, quality of
horn, cracks, rings, length and wear of the old shoes, peculiarities
in the gait, and the presence of lameness.   (2) Removal of the
old shoe by carefully lifting the clinches to prevent injury to the
horn.   (3) Preparation of the hoof for the shoe.   (4) Selection
and fitting of suitable shoes.

Horn grows constantly, so the hoof must needs be reduced in

size or prepared for the shoe at each shoeing. The experienced shoer relies upon the judgment of his eye to determine the correct relationship between the length of toe and the height of the heel. At this time he places the horse on a perfectly level floor to see that the paring and rasping have left the foot "in balance," or level, and the bearing surface suitable for attachment of the shoe. All the wall, the white line, and ⅛ inch of the sole must come in contact with the shoe, so that each part shall bear its proportionate share of the weight. The frog and bars are only trimmed in rare cases.

When the toe is left too long the heels do not perform their share in supporting the weight and bend toward and press unduly upon the frog. If more horn is removed from one side than the other, the foot is thrown out of balance and more strain and concussion placed on the side having the highest wall. This is apt to damage the sensitive structures on that side from overwork, while those on the opposite side atrophy from lack of use.

Young horses, and those kept under conditions whereby the feet are moistened at regular intervals, must be shod oftener than other animals because the horn of their feet grows faster. A four-year old should usually have the shoes set every three weeks, while an aged horse may go four weeks or longer. When the shoes are left on too long corns may develop, or the nails work loose and injure the feet and legs.

The **horseshoe** in common use is machine turned, so must be fitted to the foot before being nailed on. There are shoes for front and hind feet and for right and left feet. They should be no heavier than will suffice for about one month's wear. The fullering is the groove on the lower surface of the shoe. It aids in preventing slipping and has the nail holes punched in it. Clips are earlike projections drawn up at the toe and quarters more firmly to attach the shoe to the foot and take the strain off the nails. Calkings are placed at the toe and heels. They are useful to prevent slipping. The heel calk is turned at a right angle to the bar of the shoe. Sometimes the outer calk is turned horizontal to the bar. Summer shoe calks are blunt. Winter calks are sharp. Four-calked shoes are used to bring about certain kinds of toe action. Never-slip calks are useful for horses driven on city streets. They are objectionable, for the reason that they may break off or cause serious calk wounds. Their advantages

are the quickness and convenience of application and sharpening. If calks are turned at the heels only, the toe of the shoe must be left thicker than the branches to avoid disturbing the normal setting down of the foot as little as possible.

The **bar-shoe** is used extensively in the cities. It is especially adapted for heavy draft horses with brittle walls and heels that are weak, low, or contracted. The bar rests on the frog and thus affords frog pressure. For horses which habitually pull their shoes off, either by getting them caught or by stepping on them, this shoe is best. It should not be used if navicular disease is present. On the other hand, it is the most suitable for many other forms of disease in the feet.

The **snow-shoe** is one well beveled on the inner border of the ground surface to prevent snow-balling. It is especially useful when the snow is damp and packs easily.

The **nail plate** is made of two pieces of sheet steel riveted to a C-shaped strip of tarred canvas. The latter is interposed between the hoof and the shoe, so that the metal comes in contact with the hoof only at the heels. It is very effective to prevent nails from being picked up, and has the further advantage of cheapness.

Leather pads are useful for flat-footed horses and prevent bruising of the sole and evaporation of moisture. They are also serviceable in preventing the horse from picking up nails.

Rubber pads would be used more, especially in the cities, if they were less expensive. As a device to prevent slipping, nothing is so effective. No calks are needed if rubber pads are used, which does away with danger from calk wounds. They are the only device that satisfactorily prevents snow-balling, and allows the horse to do full work on snow-covered pavements.

Horseshoe nails have one side of the shank flat, the other concave. They are wedge-shaped in every direction which prevents splitting the hoof. The point is beveled so as to draw it in the direction of the outer or flat side where it enters the horn. It is, therefore, imperative that the nail be held with its flat surface toward the outer edge of the shoe. Nails should always enter the white line. They are driven deep enough so that their heads are flush with the ground surface of the shoe. There are a

number of different sizes. Numbers six to nine are the ones commonly used, but longer nails than necessary should be avoided.

Shoeing for special gaits and to correct faulty gaits can be no more than mentioned. It is possible to make a pacer trot by applying a special shoe. A horse that stumbles will be given relief with a roller-motion shoe; that is, one well rounded at the toe so as to cause the animal to break over quicker. Lameness from sore flexor tendons, as a result of undue exertion or knee-sprung conformation, may be successfully treated with the roller-motion shoe. Curby and spavined horses are shod with high heel calks. Weighting the shoe on the inside or outside branch is an artificial aid to straighten wide and narrow ways of going.

Overreaching is that condition where the fore shoe is struck by the toe of the hind foot before it is lifted to be taken forward. It is commonly called *forging*, from the sound like pounding a forge. At times the toe wall may be quite seriously bruised. In colts forging is often due to fatigue, and in all animals to shoeing with too long a toe which breaks the foot's axis backward and delays picking up the foot. A short body, with long legs set too far back in front and too far forward behind, is a faulty conformation especially conducive to forging. To correct this defect, shoes are applied to increase and quicken the action in the fore limb and retard it behind. The front shoe is made with short heel calks which slant forward, and no toe calk. The hind shoe has two lateral toe calks or clips and is set back a little from the toe wall.

Interfering is a striking of the supporting leg by the opposite foot. The hair is rubbed off and in some cases a severe wound is produced. The causes of interfering are fatigue from unaccustomed or overwork; bad conformation, more especially the base-wide and toe-narrow standing position; faulty or neglected shoeing. Each case must be studied and treated on its merits. A shoe with a thick, heavy outer heel calk helps to correct the improper gait.

Stumbling may be defined as inability to place the foot on the ground in the normal way, that is, heel first. It is often seen in horses with low withers, and those with relatively little slope to their shoulders and pasterns, which causes the center of gravity

to be thrown too far forward. Leg weariness, clumsiness, and unsound joints also cause this defect in the gait.

Nailprick is the most common injury to the foot and often causes very serious trouble unless given prompt attention. When suspected, proceed as follows: (1) clean away all dirt from the foot; (2) pare the horn until the place where the nail entered is found (3) rim out around this place to provide good drainage and to relieve pressure from accumulating pus; (4) apply a strong disinfectant solution or tincture of iodin by moistening bits of absorbent cotton that are to be packed into the hole and replaced next day.

DISEASES OF THE BONES AND JOINTS

INFLAMMATION OF BONE

The different parts of a bone are so closely associated in nature that it is difficult to determine whether the periosteum, the bone substance proper, or the bone-marrow is involved in the inflammatory process. Although the principles of treatment are the same for each, it is advantageous to know exactly where the inflammation is located.

Periostitis is inflammation of the periosteum or sensitive tissue covering the bone. It is the result of irritation in some form. Pain is the chief symptom of periostitis, and is severe because there is little opportunity for the tissue to swell as do the softer structures of the body. Heat and swelling are almost or quite imperceptible for the same reason. Treatment should be given in the early stages to be of greatest benefit. Rest is the remedy of most importance. The application of cold-water bandages, changed every hour or two, is an easy method of obtaining moist heat which aids in hastening recovery.

Ostitis is inflammation of the bone substance. The causes are either mechanical or infectious irritants. Among the common mechanical causes are injuries from blows, kicks, and other traumatisms. Not infrequently a non-infectious ostitis is converted into the septic form by subsequent infection with microörganisms. The chief symptom of ostitis is the appearance of a hard projection or bony swelling from the surface of the bone. Such a growth is called an *exostosis*. Exostoses may occur anywhere on the bone, but are most often seen in the region of joints where they cause lameness. They nicely illustrate nature's effort to repair the injured structures. One characteristic of exostoses is slowness of growth. It may require years for them to reach their full size. Sometimes they become reduced in size or entirely disappear, but, as a rule, after an exostosis once develops it will remain as a permanent blemish. When an exostosis occurs at a

287

joint and progresses so far that the bones of the articulation become firmly welded together, the joint is said to be ankylosed and a stiff, immovable articulation results. A dull, continuous pain is always present in ostitis. The most satisfactory treatment is the counterirritant applied either as a blister or the actual cautery.

Osteomyelitis is inflammation of the bone-marrow. It is a serious disease, but fortunately is relatively rare. Suffice it to say that infectious forms of osteomyelitis are usually incurable.

From a practical point of view there are three forms of inflammation of bone which deserve especial mention. They are bone spavin, ring-bone, and splints. Usually they all cause an exostosis to appear at the seat of the inflammation. Each reduces the value of the horse for both work and breeding purposes, but not in the same degree. When considered in order of importance they should be ranked as mentioned above, for spavin is a more serious disease than ring-bone, which, in its turn, incapacitates the horse to a much greater extent than does a splint.

BONE SPAVIN

Bone spavin is the term applied to the exostosis that occurs on the inner side and in front of the hock-joint (Fig. 73). There are three kinds or forms of spavin—viz., (1) high or "true spavin," which is the most serious; (2) low or "jack spavin," which does not interfere to such an extent with the joint; (3) occult or "blind spavin," which involves the joint surfaces, presents no enlargement, but is accompanied by marked lameness.

Causes.—Bone spavin may be caused by any object that produces inflammation—for example, faulty conformation; mechanical injuries to the hock, either from blows or kicks or from too rapid and hard work on paved streets; excessive strain upon the hock-joint from improper shoeing.

Symptoms.—Lameness is the first symptom noticeable. The horse avoids moving the joint and develops a characteristic "spavined gait," in which a slight hitch is observed in the hip on the affected side and a decided dropping of the opposite hip. This is most pronounced when the horse first starts, and results from throwing the weight of his body upon the sound leg. When driven a short distance he "warms out" of the lameness. After

he stands for a time and cools off and is then driven again, the lameness becomes much aggravated. An exostosis makes its appearance at the seat of the inflammation. No indication of the severity of the spavin can be had from the size of the enlargement which may be out of all proportion to the lameness. The toe of the shoe of a spavined horse is worn away to an appreciable extent. When standing he frequently rests the heels of the diseased leg on the wall of the opposite foot for relief.

To determine the presence and severity of a spavin the animal may be subjected to the spavin test. This is made by flexing the joint for at least a minute by grasping the lower end of the cannon with the hand and closing as completely as possible the angle formed by the leg and cannon bones. Immediately the animal is made to trot briskly away from the examiner. If a spavin is forming, the horse will show the peculiar lameness described above.

Treatment.—In treating a bone spavin the object aimed at is to hasten nature's effort toward ankylosis or union of the diseased bones. This requires transforming the existing chronic inflammation into the acute form. To accomplish this end more blood must be brought to the part. The application of blisters or the firing-iron are the means used to bring it about. Point firing, or the introduction of a red-hot pointed

Fig. 73.—The left metatarsal and lower row of tarsal bones showing a massive bone spavin. Complete ankylosis has occurred between all the bones.

firing-iron through the skin into the bone tissue, is resorted to if the blister fails. Rest is an important adjunct to the treatment

19

and is necessary for complete ankylosis. The horse should be shod with a high-heeled shoe to take the strain off the front of the joint.

RING-BONE

Ring-bone, like bone spavin, results in an exostosis, but occurs in the region of the large and small pastern bones (Fig. 74). The bones of the fore limbs are more frequently affected than those of the hind. There are unilateral and bilateral, high and low, and articular and non-articular ring-bones, depending on their exact location and extent.

Causes.—These are most often of a mechanical nature. Long sloping, or short upright pasterns, predispose to ring-bone formation.

Symptoms.—Lameness is the most evident symptom. Later, a hard swelling develops, over which the skin is freely movable. The horse "points" when standing and shows a well-marked stiffness in the affected leg when moving.

Treatment.—This will depend on the character of the ring-bone; generally it is the same as for spavin. Here, as in similar cases where the actual cautery is applied, it must be deferred until acute inflammation has subsided. By trimming colts' feet regularly, and shoeing older horses so as to straighten the foot's axis, many cases can be prevented. As a last resort unnerving may be tried.

SPLINT

Splint is a form of exostosis appearing on the fore leg below the knee. It results in an ankylosis between the cannon and splint bones. It is found in about 70 per cent. of all adult horses; in 93 per cent. of these it is said to occur on the inner side. It is pathologic only in degree, for all horses show a tendency to union of the splint and cannon bones as they are continually rubbing together. Fortunately the lameness resulting is very slight and transitory, or may not be noticeable at all. Splints may be either single or double. The so-called "pegged" splint, a form in which the growth extends across the posterior surface of the metacarpus, is more serious and interferes with the play of the suspensory ligament. Splints causing no lameness are considered to be blemishes only and require no treatment. Others are treated according to the directions given for spavin and ring-bone.

Fig. 74.—Normal and diseased digital bones of horse. The fetlock joint was rendered immovable by the encroachment of the ring-bone. The lateral cartilages have ossified into side bones.

OSTEOMALACIA

Osteomalacia is a disease of mature animals arising from general nutritional disturbances and causing an increased absorption of lime salts from the bones.   In America several outbreaks have been observed among horses, especially in regions where soil conditions were unfavorable and in dry years.

Causes.—Deficiency of available lime for the organism is the important causative factor.   Forage grown on soil lacking in phosphoric acid and lime may contain less mineral substance than the animal needs.   As an exclusive ration it would be unsuitable.

Symptoms.—Digestive disturbances, a run-down condition, and hidebound appearance are the first symptoms noticeable. Later the animal develops anemia, a depraved appetite, and diarrhea.   Lameness occurs, which is usually erroneously diagnosed as rheumatism.   Swelling of the face, a symptom of osteoporosis or "big head," a disease closely allied to osteomalacia, is seen in advanced cases.   The bones of the limbs are subject to enlargements and deformities from the deficiency in mineral matter.

Treatment.—Osteomalacia is a chronic disease and lasts for months or years.   When treatment is instituted early good recoveries may be looked for.   The affected animals should be removed to another region where soil conditions are better, or a change made in their feed.   If phosphorus is lacking, bean, pea, or clover hays are beneficial, for they contain relatively large amounts of protein.   Lime salts should be added to the diet as in rickets.

RICKETS

Rickets affects young animals only, and is due to a disturbance in metabolism.   It is characterized by the persistence of the cartilaginous tissue and the appearance of deformities in the skeleton.

Causes.—Like osteomalacia of older animals, it is caused by a deficiency in lime salts.   This is substantiated by experimental and direct observations, and may be demonstrated in animals weaned too young and deprived of the normal supply of lime previously furnished by the mother's milk.   Rickets is more often due to defective absorption of lime salts than to a lack of them in the feed.

Symptoms.—In the first stages the young animal seems weak and loses his appetite; the belly becomes bloated, and often an obstinate diarrhea sets in. The most important symptom is a disturbance in locomotion, brought about by pains and aches in the bones. Affected animals step about restlessly, move stiffly and with care, lie down much of the time, and resent being disturbed. The bones of the limbs become enlarged at their ends, producing hard, sensitive swellings at the joints. The bones may become distorted under the weight of the body or the traction of muscles attached to them. If not arrested, rickets soon leads to softening of the bones. In extreme cases the bone tissue is so soft it can be cut with a knife.

Treatment.—If treatment is not given, rickets may run a chronic course of several months, but spontaneous recoveries are not infrequent. As soon as the diagnosis is made the diet should be regulated and good quarters and an opportunity for daily exercise provided. Food rich in calcium, especially green feed, is nature's remedy. In many cases lime in the form of powdered chalk (calcium carbonate) will be found beneficial. The daily dose for foals is 10 to 20 grams. Precipitated calcium phosphate should be administered if the food is deficient in phosphates.

BONE FRACTURES

A fracture is defined as a break in a bone. Kicks, blows, and falls on slippery pavements are common accidents that may result in fracture. A simple fracture is one in which the bone is broken into but two parts and the skin remains unbroken. This form is the least serious, for healing usually takes place without infection. If the skin is wounded and one of the broken ends protrudes it is termed a compound fracture. This is very serious, for the protruding end always becomes infected. A comminuted fracture is one where the bone is broken into three or more pieces. Besides these, there may be recognized complete, incomplete, transverse, longitudinal, greenstick, double, and triple fractures.

The horse, according to records compiled from many cases, breaks the tibia eighteen times to the pelvis sixteen, first phalanx thirteen, and radius eight times. When the point of the hip is

chipped or fractured the animal is said to be "hipped." It does not often cause lameness or diminish usefulness.

Symptoms.—The first symptom of fracture is the inability to support weight, which causes the animal to go on three legs. Usually pain is evinced, although fractures of the pelvic and some other bones may be almost painless. When the fractured ends of the bone are displaced a swelling results. Other symptoms are abnormal mobility, or the appearance of an extra joint, and crepitation, or the characteristic grating sound caused by the rubbing together of the broken pieces of bone. Severe fractures greatly derange the general condition of the animal.

Treatment.—The treatment of a fracture is much more difficult in animals than in the human patient for they fight restraint. The fracture must first be reduced; that is, the ends of the broken bone replaced in the normal position. These ends must then be retained in position until "knitting" has been completed. It may be necessary to exert traction to get the ends in apposition.

Various schemes have been devised to hold the fractured bone in position. Metal or wood splints are most commonly employed. These are held by plaster-of-paris bandages, which harden on exposure to the air into a firm cast. If no skin wound is present, a thin layer of cotton batting, held in place by a woolen bandage, is applied under the cast. Care should be used not to get the bandage too tight as the circulation would be interfered with.

Slings are used to keep the patient in the standing position. A narrow stall is best, as it affords opportunity for support from leaning against the sides. Laxative, nutritious foods must be supplied with plenty of green fodder and mineral substances to aid nature in repairing the bone. Horses must be kept at least seven weeks in the slings, and should not be put to work for three months.

Complications of various kinds may follow fractures. Probably septicemia is the most common in cases where a compound fracture exists. Founder and tetanus are others. When the ends are not kept in contact during the healing process, one leg becomes shorter than the other and a permanent lameness results, or a "false joint" forms (Fig. 75).

The "knitting" of a fractured bone differs little from the healing of wounds of the skin. A jelly-like substance is poured out from the injured ends. By the action of certain cells this sub-

stance soon turns to gristle and forms a callus, or bony enlargement, which completely surrounds the fracture and firmly welds the ends together.   Cells from the periosteum and bone-marrow play the most important rôle in uniting a fracture.   The administration of small doses of phosphorus assists callus formation.
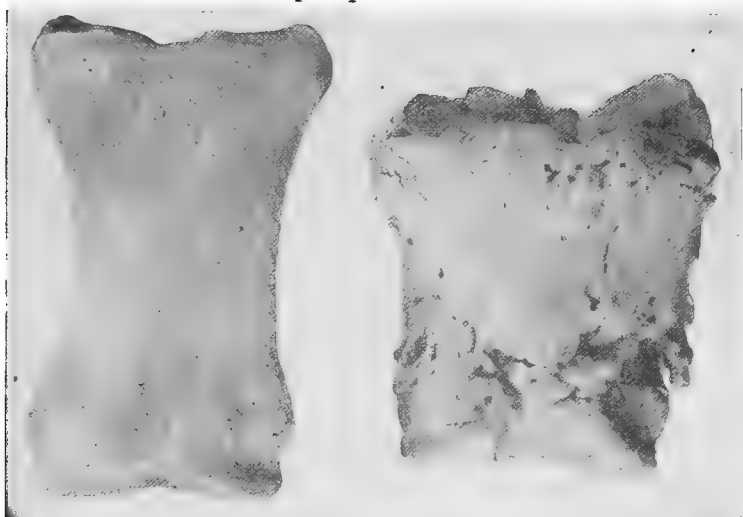
Fig. 75.—Large pasterns of same horse.   The specimen at the left is normal, the one at the right shows a knitted comminuted fracture.   Note how the fracture shortened the bone.

JOINT DISEASES

All joint diseases are accompanied with inflammatory changes. The term *arthritis* is used in a broad sense to denote any form of joint inflammation.   Serous arthritis is the most common form in mature horses.   In foals suppurative arthritis is more frequently seen, as it results from navel infection.

The most frequently occurring joint diseases are dislocations, sprains, deforming arthritis, and overfilling of the joint capsules with synovial fluid.   Any freely movable joint may become affected.   As the stifle, hock, and fetlock joints are most often the seats of these diseases, they will be taken as types for illustration.

Dislocation of the patella is displacement of this bone from the trochlea of the femur.   It may be either partial and tempo

rary or complete and permanent. The horse is said to be "stifled" when this accident occurs. Slipping when getting up in the stall, and stepping down from the stable floor to the ground some inches lower, are movements that may cause the patella to slip out of position. It may either snap back into place as soon as the joint is flexed, or catch and remain stationary at either the upper or outer side of the trochlea. In some cases it slips in and out with every step without preventing locomotion, but rendering the animal worthless, if long continued, by bringing about excessive wear on the articular cartilages. In upward dislocation the stifle joint is abnormally extended, which causes the leg to become rigidly stretched backward and makes progression almost impossible. Even with assistance the horse cannot bring the leg forward. By suddenly moving the animal backward and to the side the bone may slip back into position. If this is unsuccessful, place a rope around the pastern and lift the toe forward and upward; at the same time lift the patella upward with both hands. An audible click will be heard when the bone slips back into place. After-treatment consists in the application of a stiff blister or the firing-iron to the stifle to strengthen the tissues.

Sprain of the fetlock joint results in momentary separation of the joint surfaces and overstretching of the joint capsule and ligaments. The causes are traumatisms, like fast work on rough ground and catching the foot between planks. When passively rotated pain is severe. Within a short time swelling, heat, and lameness are noticeable. Treatment consists in rest and moist heat. The application of a plaster-of-paris bandage gives support and at the same time compression, both of which hasten recovery.

Deforming arthritis is seen in both young and old horses. Its presence is shown by a deforming enlargement of the affected joint. The causes may be infection through the navel while it is yet raw; rheumatism; traumatisms. Lameness of a transitory character that becomes gradually more persistent and permanent is the first symptom. There soon develops a sensitive swelling throughout the joint, and an effort is made to restrict joint movement as much as possible. This may shortly result in a peculiar gait even when walking. Figure 76 is a photograph of one of the author's cases. It shows erosion of the articular cartilages, distention of the joint capsule, free joint bodies, and other degenera-
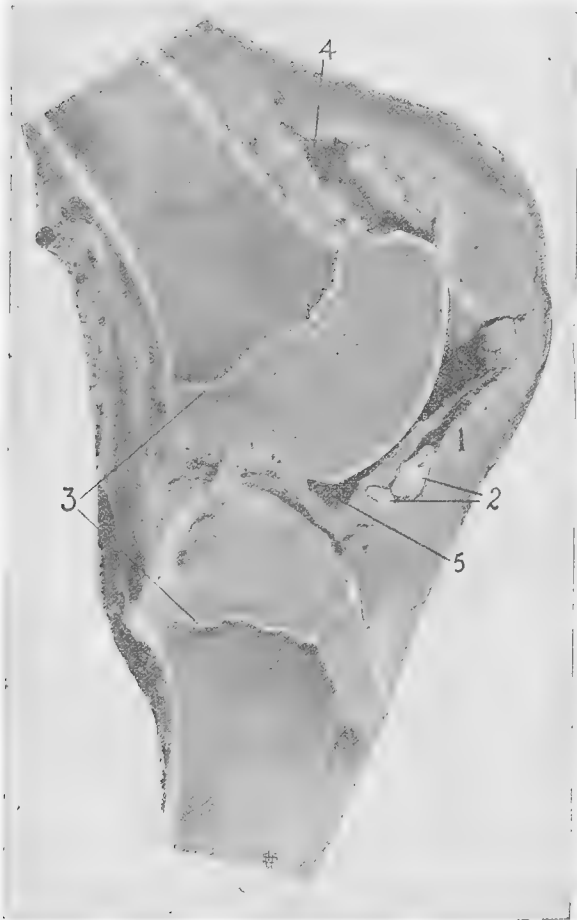
Fig. 76.—Diseased left stifle joint of horse; sagittal section passing through inner ridge of trochlea of femur: 1, Thickened synovial membrane of joint capsule; 2, free joint bodies; 3, epiphyseal lines; 4, upper extension of femoro-patellar joint cavity; 5, lower end of same.

tive and proliferative changes.   The probability of effecting a cure in this class of joint troubles is very remote.

Bog spavin is a serous inflammation of the synovial layer of the capsule of the hock-joint.   An abnormal amount of synovia accumulates in the joint cavity which causes the soft tissues around the joint to bulge outward.   Horses of all ages are subject to bog spavin, but it is more common in loose-jointed draft

Fig. 77.—Bog spavin of left hock of mule.

colts.   It rarely occasions lameness and may disappear without treatment.   The well-defined, puffy swelling is soft and situated in front and to the inside of the hock (Fig. 77).   Treatment should aim at the absorption of the accumulated fluid.   This is best accomplished by applying a special bog-spavin truss, arranged so as to bring pressure over the swelling.   Blisters afford but little relief in these cases.   The fluid may be drawn off antiseptically with a capillary trocar or aspirating syringe, but the sac

will fill again in a short time.   Tincture of iodin, applied externally, helps to absorb the fluid.   Old cases do not respond to treatment at all satisfactorily.

Thoroughpin is found associated with bog spavin.   If the latter is not large, little or no evidence of a thoroughpin will be evident. When the joint capsule that encloses the main articulation of the hock is greatly distended with synovial fluid, a well-marked soft swelling appears on the outside of the hock.   By palpating the swelling the fluid can be felt to fluctuate if the other hand is placed over the center of the bog in front of the hock.   As in bog spavin, the serous fluid may accumulate very rapidly—in some cases within twenty-four hours.   Not often does it disappear spontaneously.   Unfortunately, no reliable method of treatment is known.   The application of pressure and of massage has been followed by success in some cases, so should be tried before more heroic measures are attempted.   When the thoroughpin does not cause lameness, it is often classed as a blemish instead of an unsoundness.

DISEASES OF THE DIGESTIVE ORGANS

DISEASES OF THE TEETH

Dental troubles are very common in the horse; less so in cattle as their teeth are less complex. Unless treated, they interfere with mastication and sooner or later cause disturbances of digestion. The appearance of any of the following symptoms indicates some dental disease: holding the head to one side and cautious masticating movements; dropping food from the mouth, which is found in the manger in the form of balls; retention of food in the mouth for some time after eating; poor general condition, hidebound appearance, and scouring; tossing the head, side-lining, and occasional balking.

Decay of the teeth starts when the enamel covering is broken and the dentine is exposed to the influence of the bacteria and acids in the mouth. It is a pathologic condition which advances very slowly on account of the great resistance exhibited by this part of the tooth. The symptoms are offensive odor about the mouth; slobbering; slow, painful mastication. Eventually it leads to more or less complete destruction of the affected tooth. The teeth of man may be filled to prevent further decay, but this is rarely possible with animals. It is, therefore, difficult to save a tooth once decay sets in. The only thing that can be done is to extract the diseased tooth and to shorten the corresponding tooth in the opposite arcade, as it is usually elongated and may seriously interfere with closure of the mouth.

Alveolar periostitis results when the alveolar cavity is opened to infection. Normally the gums hermetically seal the alveolus from external influences. Treatment consists in early extraction of the tooth in the affected socket.

A **tooth fistula** is an opening near the root of a tooth through which a continuous, foul-smelling, discharge of pus escapes. The diseased tooth must be completely removed before the fistula

300

can be cured. It usually occurs in young horses and is commoner in the lower than the upper jaw.

Irregularities of wear in the teeth occur surprisingly often. They are due to unequal hardness of opposing teeth, or to congenital deformities, like a narrow upper or lower jaw. The first condition leads to the formation of sharp, enamel points that may injure the tongue or cheeks. Sometimes a wave-formed mouth results, or that closely allied irregularity, the step-formed mouth. Parrot-mouth, or overshot jaw, protruding or under-

FIG. 78.—Shear- or scissor-formed mouth. This condition might have been prevented by early use of veterinary dental instruments.

shot jaw, and shear- or scissor-formed mouth (Fig. 78) are congenital anomalies in which the teeth of the two arcades do not wear on each other. These inequalities are classed as blemishes, unless mastication is so interfered with that the animal cannot chew food properly. Sharp points can be remedied by proper floating or rasping with a special file. Other irregularities may be corrected in large measure by the veterinary dentist.

CONSTIPATION

This is not a disease of itself but a symptom of various diseases, particularly those affecting the digestive organs. It is charac-

terized by the accumulation of fecal material in the large intestine.

Causes.—Constipation occurs most commonly in the late winter after the animal has been feeding on a dry ration for a long time.   Other causes are irregular feeding or watering, constitutional weaknesses, mechanical obstructions, and lack of general exercise.   Concentrated feed with little roughage, especially when given in excess, interferes with digestion and causes constipation.

Symptoms.—Foals, in which this trouble is oftenest seen, strain, pass considerable gas, and show recurring attacks of colicky pains.   In them, as in all animals, the appetite is impaired, and they appear sluggish.   The absence of peristalsis is a certain symptom of constipation.

Treatment.—Regulate the food and drink to the needs of the animal.   Fasting for a time and then providing food of a non-irritating, easily digested character is all that is necessary in cases of simple constipation.   Rectal injections of warm water, in which a little soap has been dissolved, are very useful in mild cases, and may be easily given by means of a large syringe or a rubber tube attached to a funnel.   A pint and a half of raw linseed oil is a mild, gentle, and extremely valuable laxative for a full grown horse.   If much bloating is present, add 2 ounces of turpentine to the oil.   Drastic purgatives may cause a rupture of the bowel so should be used in small doses if employed at all.   Immediate results from a physic given to relieve constipation should not be expected.

IMPACTION

Impaction is somewhat similar to constipation, but is more serious.

Causes.—It arises from feeding excessive amounts of foods rich in cellulose and wood fibers; for example, such roughage as straw, chaff, corn-stalks, and very coarse hay.   Impaction may be the result of torsion or twisting of a loop of the bowel.

Symptoms.—All the symptoms exhibited in constipation are present, but in more marked degree.   In addition, there may be observed dullness, acute abdominal pain, and straining as if to urinate.   Masses of vegetable matter collect in large balls either

in the cecum or colon, due to failure of the muscles in the walls of the bowel to act. This leads to obstruction or stoppage of the bowels. Soon the added weight, together with the distention produced by the gases, causes overstretching of the bowel. The result is interference with its normal movements. Putrefaction of the retained fecal material sets in and there are produced poisonous substances which are rapidly absorbed. A typical intestinal auto-intoxication occurs, which may end in death at the end of a week or more. In some cases a small amount of putrid bowel contents heavily coated with mucus will be passed during this time.

Treatment.—For these cases use 1 quart of raw linseed oil mixed with $\frac{1}{2}$ ounce of fluidextract of nux vomica as one dose. The oil acts as a lubricating agent and physic, while the nux vomica adds tone to the muscular part of the intestinal walls and facilitates bowel movements. Fortunately the liver assists in neutralizing the poisons which would cause death promptly if all that formed were retained. Preventive treatment consists in providing feed that will keep the bowels loose. Alfalfa or clover hay and ensilage are the best roughages for this purpose; oil meal and bran the best concentrates.

DIARRHEA

Diarrhea is the too rapid passage of food materials and liquids through the bowels. Purging, scouring, and dysentery are other terms for this complaint. It is nature's method of getting rid of irritating substances in the bowels.

Causes.—Improper mastication of food from bad or irregular teeth, or from greedy feeding is a common cause. Indigestion, unwholesome food, intestinal worms, and bacterial infection may also cause diarrhea. It is often brought on by putting horses to work too soon after feeding them.

Symptoms.—The bowel discharges are frequent, thin, watery, and have a distinctly bad odor. Affected calves belch considerable gas. Colicky pains are frequently present. In long continued cases the patient gets thin, weak, and dull.

Treatment.—By removing the cause and correcting the ration diarrhea may often be stopped without the aid of medicines. Horses that bolt their food in an imperfectly masticated condi-

tion may be made to eat slower by placing a few stones the size and shape of goose eggs in the feed box, or by feeding hay before the grain. A physic of 1½ pints raw linseed oil should be given horses to clear the bowels of the irritating contents. If there is no improvement from the effects of the oil, give tannic acid ½ dram and gum camphor 1 dram. For calves and foals 1 to 2 ounces of castor oil in a half pint of warm milk gives good results. This is to be followed in a few hours with teaspoonful doses three times a day of a mixture of salol, 1 part and subnitrate of bismuth, 2 parts. For cattle the following prescription is recommended: beechwood creosote 20 drops, oil of cajuput ½ ounce, cottonseed oil 2 ounces. This is one dose. It may be repeated at intervals of 8 hours until four doses have been administered.

LOSS OF APPETITE

This disturbance, like constipation, is not a disease but a general symptom of disease. In cattle it is often the only symptom present, so must be handled as if it were an entity.

Cause.—It is evident that the exact cause of loss of appetite would differ in different animals. In some cases it is the result of some disturbance in the digestive organs; in others spoiled feed is the cause.

Symptoms.—Affected cattle will refuse even those feeds that they normally eat with great relish. In fact nothing is capable of tempting the animal to break his fast. In cases of long standing the feces become hard and dry, and the urine scant and highly colored.

Treatment.—The object of treatment is to stimulate the appetite. For this purpose a medicine containing an acid and a stimulant have given best results. A suitable combination is found in the following prescription: hydrochloric acid 360 parts, fluidextract gentian 180 parts, fluidextract nux vomica 120 parts, and water 340 parts. Two ounces of this medicine are mixed with a pint of cold water and given by the mouth three times each day.

INDIGESTION

There are two forms of this disease, namely, acute indigestion and chronic indigestion. The former is really a form of colic.

It is described in the next section. Chronic indigestion affects either the stomach or bowels or both of these organs. It occurs as a catarrhal inflammation of the mucous lining.

Causes.—When the liver fails to perform its work in disposing of the toxic products of digestion, or excessive gas formation occurs from the action of the bacterial flora on the ingesta, indigestion results. Both of these conditions are referable to errors in feeding, poor mastication of the food, or constitutional weakness.

Symptoms.—The symptoms of chronic indigestion are loss in condition, depraved appetite, bloating, flatulence, mucus-coated feces. The skin is dry, lacks its usual gloss, and the animal becomes "hidebound," that is the hair is long, coarse and does not shed when it should. Even the horn of the hoofs gets shelly and brittle from the general inanition.

Treatment.—In many cases all the treatment necessary is the removal of the operating causes and regulation of the ration. The condition of the teeth should be carefully examined, and dental attention given if needed. A digestive tonic, composed of Glauber's salts, 22 parts; baking soda, 18 parts; common salt, 9 parts, is good to stimulate the appetite and aid digestion. The dose is a tablespoonful on the feed twice daily. Fowler's solution of arsenic is one of the best tonics for horses affected with chronic indigestion. It may be given in ounce doses three times a day.

COLIC

Colic is the most frequent and fatal disease of horses. As ordinarily used, the term colic is very inclusive and refers to any condition in which the animal shows abdominal pain. Obviously, then, colic would include a great many painful conditions of organs situated in the abdominal cavity other than the stomach and bowels. When the pain originates from these organs **true colic** or **acute indigestion** is said to exist. When painful diseases occur in the bladder, kidneys, or any other abdominal organ except the stomach and bowels, the condition is termed **false colic.** We are concerned only with true colic, which may be of two forms, viz., **spasmodic colic** or **flatulent colic.**

Causes.—All horses are subject to colic from the relatively small size of the stomach and the complicated arrangement of the

intestines. Among the frequent exciting causes of both forms of true colic are errors in feeding, watering, and working the animal. As these factors are largely under the control of the horseman, he usually has no one but himself to blame if his charge develops colic. The disease occurs when the feed is indigestible (straw), swells rapidly (dry corn), cohesive (middlings), ferments easily (green clover), damaged (moldy fodder). A large drink of very cold water when very warm is often the cause. Another common cause is giving a large feed to the animal and then putting him at once to severe exertion.

Symptoms.—There are always two symptoms present in true colic, namely, abdominal pain or "belly ache," and suppressed or altered peristalsis. When these are found there is no doubt about the nature of the disease.

Treatment.—As the course of colic is quite rapid, and as serious complications may result, it is advisable to render aid at the very earliest opportunity. This statement has more weight when it is realized that 10 per cent. of all cases end fatally. The treatment for the two forms differs as stated in the following sections.

Spasmodic Colic.—This is the form usually seen in animals of a nervous temperament that are kept under good stable conditions. The pain is due to a sudden and violent contraction of the muscular coat of the bowels.

Causes.—Such things as undue exposure to cold drafts or rain, and a sudden change in the feed, for example substituting new oats and new hay for old, are responsible for spasmodic colic. Some horses, from natural weakness of the digestive organs, are susceptible to colic, so must be managed with care.

Symptoms.—As usually seen, the symptoms are a sudden attack of pain, lasting from five to fifteen minutes, with a tendency to recur; turning of the head toward the flank; chills due to improper distribution of the blood; pawing and stamping with the feet; profuse sweating; attempts to lie down and roll; in severe pain the horse may even violently throw himself; rapid breathing; intensification of the intestinal murmurs; assumption of an attitude like a dog on his haunches. At times the animal may strain as if trying to urinate, but this symptom must not be mistaken for a sign of "kidney trouble," which rarely occurs.

Treatment.—First-aid treatment consists in making the patient comfortable. All covering and harness must be removed im-

mediately and the animal placed in a well-bedded box-stall, where he has plenty of room to roll without danger.   Instead of administering drugs containing opiates, which was the practice until a few years ago, modern veterinarians, except in rare instances, favor stimulants as opiates have no curative effect; in fact they pave the way to impaction of the bowels, or graver conditions.   First give a rectal injection of 6 or 8 quarts of warm, soapy water to empty the rectum and induce the expulsion of gas.   A stimulating colic mixture is made by mixing 2 parts oil of peppermint, 15 parts oil of turpentine, 15 parts tincture of ginger, 15 parts ether, and 32 parts raw linseed oil.   One pint may be given at a dose.   If necessary repeat this dose in an hour.

Flatulent Colic.—This form is also known as *wind, gaseous,* and *bloat colic.*   It is characterized by the accumulation of excessive amounts of gas in the stomach and bowels.

Causes.—Fermenting foods, new hay or grass, a too rapidly eaten meal, either upon an empty or tired stomach, overeating on sound grain, or eating spoiled grain are usual causes.

Symptoms.—These resemble the symptoms of spasmodic colic with the following exceptions—the abdominal pain is not so severe, but is more constant; there is less violence shown by the patient in his attempts to get relief; a pronounced bloating occurs and the right flank often becomes very tense from distention with gas, in fact it may be so great as to interfere with the movements of the diaphragm, and the animal suffocates or the stomach ruptures; tinkling sounds may be heard when the ear is placed over the flank, but peristalsis has ceased.   As in spasmodic colic, both feed and water are refused.

Treatment.—This should be stimulative rather than sedative. Administer agents to tone up the system and hasten elimination of the irritating materials and gases from the stomach and intestines.   The stomach-tube may be used to permit such gas as has collected in the stomach to escape and to remove the stomach contents.   When the cecum is much distended with gas and the patient is distressed, a mechanical opening must be provided for escape of the gas by plunging a small trocar through the wall of the right flank.   Hypodermic injections of arecolin or physostigmin in moderate doses until relief is apparent are employed with much success.   A good remedy is made by mixing 8 ounces

aromatic spirits of ammonia with 2 ounces fluidextract of nux vomica. This mixture is given in 2-ounce doses diluted with $\frac{1}{2}$ pint of cold water every two or three hours. Another reliable remedy consists of salicylic acid $\frac{1}{2}$ ounce and powdered ginger $\frac{1}{2}$ ounce in a capsule. The animal should be kept on a restricted ration some days after the pain has disappeared. Any case of colic which does not show improvement within a reasonably short time requires the attention of a competent veterinarian to prevent complications.

BLOATING

Bloating is a digestive disorder in which an excessive amount of gas accumulates in the paunch of cattle and sheep.

Causes.—A sudden change in the character of the feed, such as from hay to green clover or alfalfa, is the commonest cause. An excessive quantity of any feed that ferments easily, such as rotten roots and spoiled silage, is likely to result in the production of gas in so large quantities that the animal becomes unable to belch it fast enough, especially when so much food has been consumed that the opening into the esophagus is partially occluded. This disease usually occurs when the forage is heavy with dew or rain and the atmosphere very humid, as these conditions favor fermentation.

Symptoms.—Bloating is very easy to recognize from the sudden and marked distention of the left flank. This part becomes so tense from the pressure with gas that a sound similar to that obtained from a drum-head is heard when it is thumped with the finger. The animal ceases to feed, has difficulty in breathing, becomes uneasy, moans, and gasps for breath. These symptoms are due to interference with belching, the "safety valve" for the liberation of gas from the paunch. Death from suffocation or rupture of the stomach may occur unless prompt relief is given. It is evident that most of these symptoms are due to pressure on the lungs, large blood-vessels, and soft organs, and to the resorption of the gas.

Treatment.—In severe cases an artificial opening through the paunch wall must be provided for the escape of the gas. A trocar and canula (Fig. 79) is plunged into the most prominent portion of the left flank. The point of the instrument should

be directed downward and forward toward the right elbow. The trocar is then withdrawn, leaving the canula in place.   Usually the gas rushes out with a distinct hissing noise. To prevent further gas formation give the animal a drench of two ounces of turpentine in a pint of raw linseed oil. In some cases a rubber tube passed down the gullet into the paunch provides a suitable outlet for the gas.   By not turning cattle and sheep out until the moisture has dried off, many cases can be prevented.   In addition, a full feed of dry roughage, such as the animals are accustomed to, just before turning them out should be provided as a means of prevention.   As some animals are more likely to bloat than others, they should be carefully watched.

FIG. 79.—Trocar and canula for the relief of bloat in cattle and sheep.

CHOKING

Choking is the lodging of some object in the esophagus.   It occurs more often in cattle than other animals.

Causes.—The most frequent cause is swallowing a piece of root, an apple, or a potato so large that it cannot pass down the gullet.   The bolting of dry feed may also be a cause.   Animals with a constriction in the esophagus from any cause are subject to choking from slight provocation.

Symptoms.—Cattle drool saliva from the mouth, make frequent attempts at swallowing, bloat rapidly due to closure of the outlet for gas from the stomach, and switch the tail.   If the obstruction is in the region of the neck it can be felt from the outside.   Horses become excited, squeal, and thrust the head forward.

Treatment.—Attempts should be made to work the object up into the mouth rather than to force it down into the stomach, as the wall of the esophagus might be ruptured. A speculum to hold the mouth open is applied and the hand inserted into the animal's throat to grasp and remove the obstacle. A hypodermic injection of arecoline to stimulate the secretions is very useful and often all that is necessary. Should marked bloating occur, the stomach wall must be punctured as described in the preceding section.

INFLAMMATION OF THE BOWELS

Another term for this disease is enteritis. In this affection the mucous lining of the intestines becomes greatly congested and inflamed. It is acute, severe, and usually fatal, so is one of the most serious diseases of animals.

Causes.—In practice enteritis most frequently appears as a sequela of indigestion. When twists and folds of the intestines that interfere with the circulation occur, they cause intense enteritis.

Symptoms.—At first the symptoms are similar to those of colic, but are more pronounced in every way except the abdominal pain. In the mild form of enteritis the appetite is irregular, there is some abdominal soreness and pain after meals and considerable lassitude. The feces have a bad odor and are soft. In the severe form these symptoms are aggravated. The case is ushered in with severe chills and fever above 103°F., as a rule. The pulse is hard, fast, and wiry; the respirations are hurried and oppressed; the visible mucous membranes become deeply congested. When the animal lies down it does so very carefully. Pressure over the abdomen causes pain and will be resented. An anxious, distressed expression is noticeable, and the patient either paws continuously or walks around in his stall until exhausted. The disease is usually fatal.

Treatment.—Little can be done by way of treatment other than to mitigate the animal's sufferings. Ounce doses of laudanum in a quart of linseed tea will relieve the pain and act as a dressing to the inflamed lining of the intestines. No food should be given until signs of recovery are observed.

DISEASES OF THE URINARY AND REPRODUCTIVE ORGANS

URINE AND URINARY ABNORMALITIES

Abnormal color of the urine occurs from several causes. When the urine is red, either red blood corpuscles, or the red coloring matter of these corpuscles is present. The former condition results from severe inflammation of any portion of the urinary tract. Injuries to the bladder from bladder-stone is a common cause. When collected in a glass and allowed to stand, the blood-corpuscles appear as a red sediment. In azoturia the urine takes on a dark-brown or coffee color from the presence of large quantities of free hemoglobin (hemoglobinuria).

Abnormal turbidity of the urine is uncommon. The turbidity is due to the large amount of lime and magnesium salts in the urine. The urine of the horse is normally turbid; that of the cow clear. When the pelvis of the kidney or the bladder becomes infected with pus-producing organisms the turbidity of the urine is increased. A viscid, gelatinous sediment occurs in these cases due to the presence of a large amount of mucin.

Abnormal quantity of the urine is a frequent occurrence. An affected animal is said to have polyuria. It is a symptom of diabetes, and is also due to over-stimulation of the kidneys from improper feeds or to reckless administration of diuretic medicines. The patient shows great thirst, a depraved appetite, and a rough coat. A decrease in the quantity is due to fever, weakness, or sweating.

Abnormal frequency of urination is a very disagreeable vice, confined mostly to mares. They will stop at frequent intervals to pass small quantities of urine. It may be caused by irritation from a stone in the bladder or by nervousness coincident with the period of heat.

Inability to urinate often complicates azoturia, colic, and other diseases. It is due to a paralysis of the muscles in the bladder

311

walls or to a spasm of the muscle which guards the opening into the urethra.   In the male, strictures in the urethra, an accumulation of smegma or salts of urine in the sheath, and other mechanical obstructions may close the opening of the penis so as to interfere with the escape of urine.   The important symptom is a frequent effort to urinate.   If standing, the animal stretches out and violently strains, but either can pass no urine at all or only a few drops.   The pain caused by the distention of the bladder walls is evidenced by groaning.   By palpation through the walls of the rectum the greatly distended bladder can be felt. In the mare and cow, pressure upon the bladder causes the urine to flow out in a stream.   The bladder of the stallion or gelding can be emptied best by use of the catheter.   Where tumors or other mechanical objects press upon the urethra the only permanent relief is completely to remove the obstructions.   If the sheath is foul from an accumulation of dirt and smegma, it should be carefully washed with warm water and castile soap and then greased with vaselin.

Nephritis or inflammation of the kidneys is a rare disease in animals.   The reason for mentioning it is to emphasize the fact that many times errors are made in diagnosis, and diseases originating or located elsewhere are referred to the kidneys. Soreness in the muscles of the loin from overexertion or exposure to cold is commonly diagnosed as nephritis, because the animal exhibits tenderness when pinched.   If the temperature is elevated, the urine abnormal in quantity or quality, and the legs swollen, there is a greater certainty that the kidneys are inflamed.   In this event they should be relieved from work by eliminating waste products through the alimentary tract and skin.

STERILITY

Sterility is the inability of the male to fertilize the ovum of the female.   There are two forms of sterility, viz.: (1) Complete or permanent and (2) incomplete or temporary.   The first form exists when the animal is unable to complete the act of copulation; the condition resulting is known as **impotency**.   In the second form the coital act, which includes the ejection of semen, may be completed, but the semen does not contain spermatozoa that are capable of fertilizing the ova; the resulting condition is **azoöspermia.**

Causes.—Alterations of the genital organs which interfere mechanically with copulation are the usual causes of complete sterility. Most common among them are: injuries of the testicles, penis, or prepuce resulting in chronic inflammation; paralysis; tumors of various kinds in these organs; malformations and defects of a congenital nature such as cryptorchidry, atresia, fissure. Temporary sterility may be due to the following causes: infectious diseases; masturbation; excessive use for service; idleness resulting in overfatness; painful conditions in the loins, croup, stifle or hock which make it difficult or impossible for the animal to mount.

Treatment.—There is little that can be done to relieve impotency. In most cases it is better to castrate affected animals, for they are worthless as sires. Impotent bulls should be tested for tuberculosis, as this disease has frequently been found to involve the genital organs.

In cases of temporary sterility the cause should be removed and remedial measures directed toward the seat of the trouble (see causes). Proper feed, exercise, and care in arranging the number and times of service will be helpful in correcting faulty body processes, and will aid the animal to retain his prepotency for a longer period.

BARRENNESS

Barrenness is the inability of the female to produce living young. It may be either (1) absolute or (2) relative. In the first form conception does not occur. In the second form the prospective mother is unable to bring the fetus to term and abortion or premature birth eventually occurs. Strictly speaking, the latter form does not constitute true barrenness; it does, however, from a practical standpoint for the owner receives no return on his investment.

Causes.—As barrenness is a symptom of disease and not a disease itself, it can have a great many causes. Probably the commonest cause is some disease of the uterus. This organ is often the seat of a chronic inflammation (metritis) due to infection introduced as the result of retained placenta, abortion, or maltreatment. Purulent metritis is present in about 50 per cent. of the cows that are barren. In these cases considerable quantities of pus will be found in the womb on examination.

The ovaries are frequently at fault. Among the diseases of the ovaries that inhibit functioning may be mentioned cysts, degenerative changes, tumors, and congenital defects. Occasionally tuberculosis of the uterus or ovaries is the cause. Advanced age, overfatness from close confinement and lack of exercise, or poor condition are also infrequent causes.

Symptoms.—The affected animal fails to conceive after repeated service, or, if she does conceive, aborts her fetus before it is capable of living a separate existence. In some cases she never comes in heat, in others she is in heat all the time (nymphomania).

Treatment.—The first thing to do is to determine the condition of the uterus. This is best done by introducing a non-irritating fluid and then drawing it off for inspection. In the mare this is not very difficult during the period of heat as the cervix is then more or less relaxed and will allow the passage of a return flow irrigator or uterine catheter. In the cow it will usually be found necessary to grasp the lips of the cervix with a long forceps and draw it backward where it can be held firmly so that a small size catheter may be introduced. By careful manipulation the cervical canal can be dilated to permit the passage of a larger catheter. A normal salt solution made by dissolving two level tablespoonfuls of salt in one gallon of freshly boiled, warm water is recommended as the best douche. The old practice of dilating the os uteri and then having the animal served is no longer considered necessary, although artificial insemination has been used with success when it was impossible to find a specific cause for barrenness.

RETAINED PLACENTA

The retention of the afterbirth or "cleanings" occurs less frequently in the mare than in the cow and ewe.

Causes.—Infection of the uterus with germs is the commonest cause of this disease, which usually accompanies abortion and often results in barrenness.

Symptoms.—The fetal membranes instead of coming away of their own accord shortly after parturition, remain attached in the uterus. Portions are usually to be seen hanging from the vulva.

Treatment.—Force should never be used to remove a placenta, as the womb is always inflamed and serious damage would result. By gently pulling on the protruding portions, the entire mass may often be loosened and after a few hours will come away of its own accord. If it does not, several gallons of blood-warm normal salt solution, made by dissolving two level tablespoonfuls of common table salt in one gallon of freshly boiled water, should be introduced into the womb. This solution must be siphoned or drained off after a short time. The douching should be repeated each morning and evening until the membranes loosen and are easily detached. It ought to be continued twice daily thereafter until every shred of tissue has been washed away.

INFLAMMATION OF THE UTERUS

Metritis, the scientific term for this disease, is a more serious affection than is generally realized, as the uterus may become damaged to such an extent that the animal will be unable to bear young afterward.

Causes.—Decomposition of blood and remnants of the afterbirth following parturition and the growth of poison-producing germs in the uterus are responsible for most cases. The poisons are quickly absorbed and blood-poisoning is the inevitable result.

Symptoms.—A fever, chills, loss of appetite, shrinking of the udder, reduction of the milk flow in the mother and digestive disturbances in the suckling occur in about the order mentioned.

Treatment.—Unless the accumulated fluids and placental fragments are soon removed, the symptoms become more aggravated and acute laminitis develops. Copious irrigations with warm 0.5 per cent. carbolic acid or other suitable antiseptic solution will serve as a means to cleanse the uterus. Care should be taken that all the fluid is removed, for the uterine walls are incapable of much contraction. This may be accomplished with swabs of surgeons' absorbent cotton. Swabbing with tincture of iodin without irrigating gives remarkably quick relief.

PROLAPSE OF THE UTERUS

In this accident, which only occurs very soon after the act of parturition, the uterus "turns wrong side out" and protrudes

from the vagina as a pear-shaped, dark-red mass. When the severe straining incident to expulsion of the fetus is continued after the young is born, there is a decided probability that the uterus will prolapse. To replace the organ in its normal position requires the skill of an expert veterinarian. Great care must be taken to cleanse the exposed mucous surface of all dirt and filth. Stimulants to support the patient and medicines to ward off wound-infection diseases must also be administered. By elevating the hind quarters by means of a block and tackle the protruding parts may be replaced with ease, in fact in the cow they sometimes slip back into proper position almost of their own accord.

RUPTURE OF THE UTERUS

This accident almost always occurs during parturition or shortly afterward. In the former case it is due to puncture by one foot of the foal, or by instruments carelessly handled. After parturition it occurs from carelessness of the attendant when examining the womb or introducing fluids to irrigate it. Death is the usual result, as peritonitis is bound to set in. Moreover, it is very difficult, if not impossible, to sew up the rent in the uterine wall in a satisfactory manner.

DIFFICULT PARTURITION

The scientific term for this trouble is dystocia. It may be due either to some defect of the mother, as a deformity or disease of the pelvic organs, or to some abnormality in the size, form, or position of the fetus. All that may be required is the straightening of a retained leg, or the turning of the head, to place the fetus in position so that the animal can proceed with the act of parturition. Unfortunately, in practice the difficulties are often much more serious and can be overcome only by resort to all the skill and resourcefulness possessed by an experienced veterinary obstetrist. Therefore, no time should be lost in calling him, and this before traction is exerted on the fetus, for the chances of a successful delivery become rapidly less if assistance is delayed until the water-bags are ruptured, their contents escape, and the animal is exhausted from continued straining. Moreover, every time the hand or an appliance is introduced in the vagina the

mucous membrane lining this organ is damaged more and more, so becomes less resistant to attack by the myriads of germs that are present waiting for an opportunity to invade the tissues and produce inflammation.

ACCIDENTAL ABORTION

Abortion is the expulsion of the fetus before the period of gestation is completed.   It is also known as miscarriage and premature birth.   Mares are more subject to accidental abortion than are cows

Causes.—Accidental abortion may be the result of a kick, fall, slip, strain, horn thrust, or similar accident.   These causes are far less frequently responsible for abortions than is popularly believed.   One well known authority even goes so far as to say that no authentic case of accidental abortion in the cow has been recorded.

Symptoms.—In typical cases the udder becomes swollen, the external genitals congested, and a vaginal discharge occurs a few hours to a few days before the fetus is expelled.

Treatment.—At the first suspicion of abortion the animal should be removed to a box stall.   The aborted fetus, membranes, and soiled litter must be disposed of at once in a sanitary manner, for it should be borne in mind that later developments may show infection with the germ that causes the contagious form to have been the cause.   The ration for a few days should be laxative in character and limited in quantity.   In case the placental membranes are retained, proceed as directed in the discussion of this condition.

GARGET

The disease known as garget is also termed caked udder, mammitis, and mastitis.   In a broad sense it is any inflammation of the mammary gland.   It occurs most frequently in the dairy cow because her udder has been developed by careful breeding to a wonderful capacity, which renders it more subject to disease. There are two forms of mastitis, one is not transmitted to other cows, while the other is.

Causes.—It seems certain that most cases are the result of an invasion by a number of bacteria.   The form of the affection

which is transmitted from animal to animal is caused by a streptococcus. Many cases appear to be brought about by mechanical injuries which make possible the entrance of the bacteria of the skin or those normally present in the udder. Other cases may be due to infection through bacteria gaining entrance to the udder through the teat. The microörganisms are more likely to cause trouble just before or shortly after the cow calves. Exposure to cold drafts or by lying on cold, damp concrete floors is an indirect cause. Unless prompt relief is given, one or more quarters of the udder may become permanently damaged.

Symptoms.—These appear suddenly and are well marked in most cases. Little milk can be drawn from the affected quarters and that which does come is watery and clotty in appearance. In severe attacks the cow develops a fever; the udder becomes red, hot, swollen, hard, and painful; lameness occurs when walking, as a result of pressure on the udder by the thighs.

Treatment.—In simple cases garget can be relieved by administering a saline cathartic, by providing a laxative ration containing little or no high protein feeds; by applying woolen cloths, wrung out in hot water, for half an hour at a time two or three times a day, then drying the surface quickly and anointing with cottonseed oil or unsalted lard rubbed in well with the palm of the hand.

That form of mastitis which affects several cows in the herd at one time and has a tendency to spread calls for a more extensive line of veterinary treatment than can be described in a work of this kind.

When a cow is being dried off previous to freshening, her milk should be carefully inspected for evidences of garget. If this condition is found, the drying off process should be deferred until the milk appears normal. This may call for stripping three times a day. It is much better to milk the cow up to the time of calving than to run the chance of drying her off while the udder is diseased, for she is likely to develop a serious form of mastitis when she freshens.

ANIMAL PARASITES AND PARASITIC DISEASES

GENERAL CONSIDERATIONS

All animal parasites attacking domestic animals belong to the invertebrates. They are living organisms which obtain their sustenance in whole or in part from their host—the animal they infest.

The **occurrence of parasites** is more frequent than is generally recognized. All species of farm animals are attacked. Often quite badly infested cases are overlooked because the parasites are so small that they escape notice or are not looked for intelligently.

The **effects of parasitism** depend on the kind, number, and position of the invaders. Injury is caused by animal parasites from irritation; from drain by feeding upon the tissues and juices; from poisoning caused by toxins produced by the parasites; from their wanderings in and destruction of the body tissues; from interference with absorption in the intestines; from obstruction of the natural passages of the body.

The **diseases produced by parasites** are quite numerous. The most common are: pneumonia, bronchitis, indigestion, colic, liver rot, gid, measles, mange, lousiness, and Texas fever. Greater losses occur in the south than in the north where the early and late frosts and rigorous winters destroy the eggs and larvæ. Sheep are more subject to attack by animal parasites than other species of farm animals because they are less resistant; eat the grass closer to the ground, thus having a greater opportunity to pick up eggs; and afford protection to external parasites by their heavy fleeces.

The **symptoms of parasitism** vary with the position of the parasites. External parasites may cause the following symptoms: itching, dry skin, rough hair, loss of hair. Internal parasites may cause: unthriftiness, emaciation, malnutrition, constipation

319

or diarrhea, abdominal or muscular pains, jaundice, anemia, cough, and abscess formation.

The **diagnosis of parasitic diseases** depends largely on the finding and determination of the parasites or their eggs. A postmortem examination is often necessary before a diagnosis can be made. The collection of parasites from the stomach and bowels of animals to identify them is best done by placing the contents in a jar of water and stirring it vigorously. After allowing the mixture to settle to permit the worms to collect at the bottom, the fluid is decanted off, more water is added, and the process repeated. Finally all the water is poured off and normal salt solution is added. This mixture is then poured into a shallow dish where the worms are easily seen.

The **prevention of parasitic diseases** is largely a matter of maintaining stock in a sanitary manner. Plenty of good feed is more important than anything else, for animals in good condition are less likely to respond to attacks by parasites than those in poor condition. By keeping the skin and hair coat of animals reasonably clean, external parasites can be prevented from gaining a foothold. Many internal parasites enter the body as larvæ with the food and drink which should be carefully guarded against contamination with their eggs and grubs. The following salt mixture has been found very helpful in keeping sheep and cattle free from stomach and intestinal worms: common salt 280 parts, dried iron sulphate 16 parts, powdered charcoal 12 parts, and flowers of sulphur 8 parts. These ingredients are ground or well mixed together and kept in covered boxes within ready access at all times. Eastern sheepmen try to secure new stock from western ranges every third or fourth year as western sheep seldom harbor the parasites which are prevalent in the East for the reason that the ranges are so dry that the parasitic eggs cannot live. When these methods of prevention fail it will be found best to dispose of the particular species of animals that is affected and not restock for a year. In this way all eggs in the soil will be destroyed and the farm made safe. Never allow the stock to range over the entire farm as it would then be impossible to rotate the pastures as may be necessary in certain cases. Furthermore, pastures should not be top-dressed with stable manure when they are to be used for grazing animals the following season. The long-continued pasturing of one class of animals upon

the same pasture or over-stocking is a certain way to infect stock with parasites which are injurious and which may cause death.

The **classification of parasites** is based upon their life history. External parasites live on the skin of animals; internal parasites live in the internal organs; permanent parasites spend their entire life with one host; temporary parasites spend but a part of their existence with one host; facultative parasites have the power to change from one host to another of a different species; obligatory parasites can live only on or in one species of animal.

The **kinds of parasites** most commonly found attacking farm animals fall into five groups or classes as follows:

Trematodes, flat, leaf-like organisms of which the flukes are an example.

Cestodes, ribbon-like organisms of which the tapeworms are an example.

Nematodes, round, pencil-like organisms of which the round worms are an example.

Insects, organisms provided with three pairs of jointed legs, such as lice and flies.

Arachnids, spider-like organisms provided with four pairs of jointed legs, such as mites and ticks.

TREMATODES

Liver flukes (Fasciola) are the only parasites belonging to the trematodes of much economic importance. They have soft, non-segmented bodies. They infest the livers of sheep and cattle which have access to low marshy pastures. One stage in the life of this parasite is passed in the mantle cavity of certain fresh water snails, from which it migrates and crawls upon grass blades. When infested grass is eaten by sheep or cattle the parasites gain admission to the body and find their way up the bile duct. That condition known as "liver rot" is produced. No drug has been found which will rid animals of the flukes. As well nourished animals are less apt to acquire flukes, it follows that all infested animals should be fed well. Prevention consists in keeping susceptible animals from moist, low-lying land. A plentiful supply of salt within easy access of sheep is useful in preventing infestation.

21

CESTODES

Tape worms (Tænia) are the most common representatives of the cestodes. Cattle in America are infested with three larval and two adult tapeworms. Our sheep harbor four of each. Tape worms never occur in hogs and are rare in horses. These worms have flat, ribbon-shaped bodies that are segmented. They are provided with sucker-like disks by which they attach themselves to the lining of the intestines. Instead of a digestive tract they are provided with minute openings on their bodies through which nourishment is absorbed. Each segment is complete in itself and capable of self-fertilization, for it is a true hermaphrodite, possessing both male and female genital organs.

Man acts as the host for two tape worms that pass their larval stage in food-producing animals. The disease is contracted by man through eating raw or rare meat containing the larvæ. Animals in turn become infested as a result of consuming the eggs of the tape worm with food or water contaminated by the feces of man. The term measles is applied to infested meat on account of the small cysts containing the parasites which may be seen on close inspection to stud the meat.

The **beef measle parasite** (Cysticercus bovis) is the intermediate stage of Tænia saginata, a human tape worm. The cysts are from $\frac{1}{4}$ inch to $\frac{3}{4}$ inch in diameter and are found in the muscles of the heart, tongue, jaws, and diaphragm of cattle. Since the parasite dies if the beef carcass is allowed to hang for thirty days in the cooler, the federal meat inspection laws make this requirement instead of condemning infested meat as unfit for food. Raw measly beef is to be viewed as injurious to man.

The **hog measle parasite** (Cysticercus cellulosæ) is the larval stage of Tænia solium, a human tape worm. Heat is required to kill pork measles, so affected carcasses are rendered into lard, unless the infestation is excessive, in which case the carcass is condemned.

NEMATODES

Round worms of various kinds are classified under this head. They are characterized by having round bodies and a complete digestive apparatus. A number of different species are found

inhabiting organs of the digestive, respiratory, and circulatory systems. Some are so minute as to be almost invisible to the naked eye, while others attain a length of 12 inches or more when fully developed. They cause damage by interfering with the functions of the infested organs. The effects are unthriftiness, emaciation, diarrhea, anemia, and even death.

The **large white worm** (Ascaris megalocephala) is frequently seen in the feces of the horse. The male of this variety measures
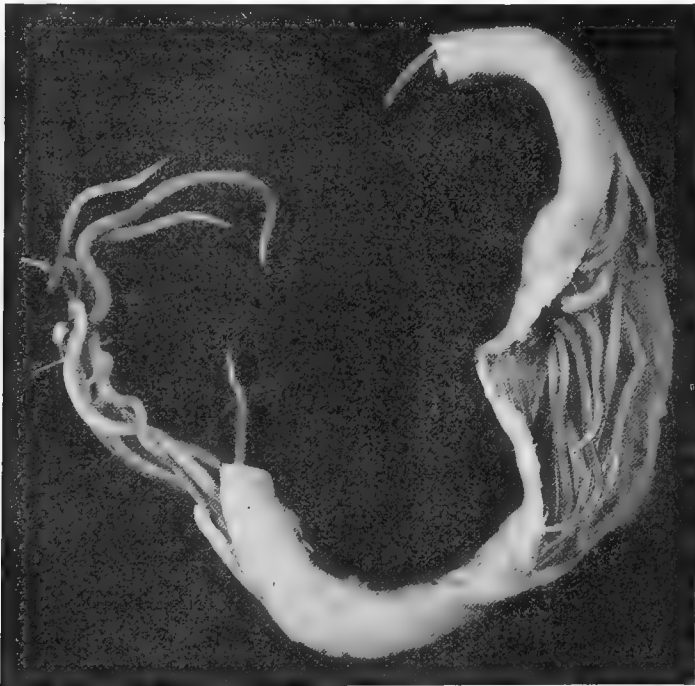
FIG. 80.—Large round worms in a portion of the small intestine of a hog.

from 6 to 10 inches long, while the female may exceed 14 inches in length. They produce digestive disturbances, and may even mechanically clog the intestines if present in large numbers. A diagnosis is made by finding one of the adults or its eggs.

A successful remedy to rid horses of Ascaris is 15 grams of tartar emetic dissolved in 15 quarts of water. The dose should

be repeated after fourteen days regardless of the number of worms removed. Keep the horse from drinking until he is thirsty, then set the bucket of tartar emetic solution before him and allow no other water until it is all drunk.

The large round worm (Ascaris suis) is harbored in the intestines of swine (Fig. 80). The best anthelmintic for ascarids in swine is oil of chenopodium. Most satisfactory results follow if the oil is given alone instead of mixing it with the feed. The dose is 4 cubic centimeters for a 75 to 100 pound pig given in 1 ounce of castor oil. Each pig should be fasted for twenty-four hours before being given this medicine.

The **thorn-headed worm** (Echinorhynchus gigas) is also commonly found in the intestines of swine. Although not belonging to the class of round worms it is described here for convenience. In large numbers they cause symptoms which are frequently confused with hog cholera. A heavily infested animal shows persistent unthriftiness, digestive disorders, and fails to respond to the hog cholera serum treatment. The mature worms are white and measure from 8 to 10 inches long. They are usually found with the head firmly imbedded in the wall of the hog's intestine. Not infrequently the head has perforated the bowel rendering it unfit for sausage casings. Their life history is very interesting as a secondary host is required. Hogs become infected through eating the large June bug, or its grub, which contains the larvæ of the worm. The beetle or grub thus plays the part of an intermediate host.

The **lung worm of sheep** (Strongylus) is a very small, threadlike worm which produces verminous bronchitis. It will serve as an example of this class of worms. Various names have been given to the disease produced by lung worms, viz., hoose, husk, and paper skin or lamb disease. The worms are also found thriving in the bronchial tubes and lungs of pigs and calves. Among the symptoms which result are: a cough which comes on in spasms, loss of appetite, a dry and harsh skin, accelerated breathing, anemia, and bronchitis and pneumonia. During favorable seasons an entire flock of sheep may become diseased and large numbers die. Death is usually directly due to suffocation by plugging the air passages. Treatment is not satisfactory. However, a mixture containing equal parts of turpentine, chloroform, and olive oil injected into the trachea has been used.

Unless carefully handled, pigs and lambs may succumb to the treatment. For this reason none but an experienced person should attempt to administer the medicine.

The **stomach worm of sheep** (Hæmonchus contortus) is red or white in color according to the amount of blood sucked into its intestine from the mucous lining of the stomach of the host. The male worm is from $\frac{1}{2}$ to 1 inch in length and the female from 1 to $1\frac{1}{2}$ inches. They inhabit the fourth stomach and appear as myriads of short, hair-like bodies. Lambs infested with this parasite fail to thrive, have little appetite, are dull, thirsty, weak, and may scour. In bad cases the belly enlarges, the wool becomes harsh, the skin pale, and the lining of the eyelids white or pale in color. At this stage the most characteristic symptom of the trouble is the appearance of a dropsical swelling under the jaw. Gasoline has given good results as a remedy. It is administered to each well grown lamb in half ounce doses (one tablespoonful) mixed in 6 ounces of milk, for three successive mornings before feeding. Copper sulphate in 1 per cent. solution has been found to be very efficacious against stomach worms in sheep. The dose is 100 c.c. for sheep a year old or older, and 50 c.c. for lambs under a year old.

The **nodular disease worm of sheep** (Œsophagostomum columbianum) is a thread-like, round worm. It measures about $\frac{1}{2}$ to $\frac{3}{4}$ inch long and is found in the intestines. The eggs, which are passed out with the feces, contaminate food and water and are hatched outside the body. When the parasites are taken into the host and reach the intestines they immediately penetrate the bowel wall and there produce the characteristic nodules, about the size of a pea, that are seen on the outer surface of the gut and from which the disease gets its name. In badly infested cases the mesentery, liver, and other surrounding organs may be studded with the parasitic nodules. If a nodule is opened it is found to contain a green, cheesy pus and usually the parasite. The disease can be distinguished from tuberculosis by the fact that neighboring lymph glands are not involved. Besides, tuberculosis is extremely rare in sheep, so there is little danger of confusing the two. Injuries produced are according to the extent of the infestation, vitality, and age of the sheep. If few worms are present it is not especially serious. In large numbers the nodules prevent the absorption of food material.

The "bare-lot" method of prevention in which the lambs and ewes are kept separated in adjoining pastures, with a bare earth lot between into which the lambs until weaned are frequently turned with the ewes for sucking, has given good results. The ewes and lambs are returned to their proper pastures after each sucking period. Lambs so raised at the Bureau of Animal Industry experiment station at twelve months weighed on the average 82 pounds, while lambs pastured with the ewes at thirteen months weighed on the average only 70 pounds. On postmortem examination no nodular infection was found in lambs managed as above, while the others were all infested.

Trichinæ are small, slender worms scarcely visible to the naked eye. They live in the intestine of man and other animals. Man acquires the parasite through eating fresh pork containing the living larvæ of the parasites. Hogs become infected through eating the flesh of other hogs or rats. The disease produced is commonly known as trichinosis. The adult worms develop from the larvæ and produce embryos which penetrate the intestinal wall and lodge in the muscles. Here the embryos coil up, become encysted, and may be seen with the aid of a microscope.

From two days to two weeks after infestation, the following symptoms are exhibited by man: loss of appetite, nausea, abdominal pain, diarrhea, and fever. After the parasites reach the muscles the latter become tense, swollen, and painful. In light cases recovery occurs in about two weeks; in severe cases not until several months. In fatal cases death does not occur until several weeks after the patient ate the infested pork.

The symptoms of trichinosis in hogs are slight and usually pass unnoticed, for hogs do not die of the disease.

Since nearly 2 per cent. of all hogs in this country are affected with trichinosis, it is apparent that persons should take precautions to prevent infection. The danger may be entirely avoided if pork is thoroughly cooked. By refraining from eating pork in the raw state, including dried or smoked pork products, man need have no fear of contracting trichinosis.

INSECTS

Lice are small, wingless insects. The females lay oval eggs, called "nits," and secrete a glue-like substance that attaches the

eggs to the hair.   After a varying period the young and complete insect raises the operculum from the large end of the egg, opposite to the point of attachment, and crawls out.   In a short time it develops into an adult louse and is capable of reproduction. Lice multiply very rapidly under warm, moist conditions.   Infested animals are said to be lousy.

Each species of animals is attacked by two or more kinds or species of lice.   As a rule, the lice of cattle will not pass to horses, hogs, or poultry; the reverse is also true.

The horse is commonly infested with one of two species of lice, but rarely with both at the same time. The Hematopinus macrocephalus is characterized by a long, narrow head and large, oval abdomen (Fig. 81).   It measures slightly more than $\frac{1}{16}$ inch long, and obtains its living by biting and sucking the blood from its host.   The Tricodectes pilosus has a head that is rounded in front and is broader than it is long.   This louse lives principally on the epidermal scales of the horse.   It is about half the size of the former.

The lice found most frequently on cattle belong either to the blood-sucking species, commonly known as "blue lice," or the biting species, commonly known as the "little red louse."

Fig. 81.—The common horse-louse (Hematopinus macrocephalus) greatly enlarged.

There are three methods of applying treatment to eradicate lice, viz., hand applications, spraying, and dipping.   The method adopted will depend on the season of the year, remedy selected, and number of animals to be treated.

Hand applications are applied in the form of dusting powders, and liquids.   The insecticidal value of dusting powders for lice is questionable, although many different kinds are on the market. Ointments are useful if properly compounded.   Probably "blue ointment" is most effective, but it contains bichlorid of

mercury so is very poisonous and cannot be used with safety
except on poultry.   Kerosene emulsion or kerosene with equal
parts of cottonseed oil is an effective remedy when applied
thoroughly and repeatedly.   Foremost among the liquid in-
secticides are the various commercial coal-tar dips.   The latter
should be used in accordance with the directions of the manufac-
turer as printed on the label accompanying the original package.

Spraying is the method used when the number of animals
to be treated is too large to justify making hand applications,
or too small to justify providing a dipping vat.   Any liquid
insecticide mentioned above may be applied as a spray.   Two or
more treatments should be given fifteen to sixteen days apart.
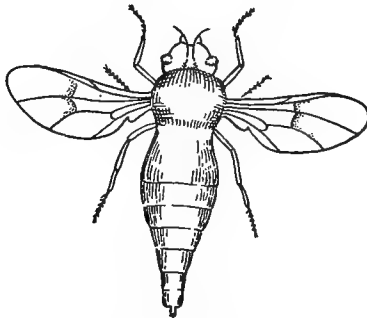
Fig. 82.—The bot-fly of horse   (Gastrophilus equi).   An adult female magnified
about three diameters.

Dipping consists in immersing animals in a vat containing a
liquid that will kill external parasites.   To be successful, dipping
must be performed carefully and thoroughly.   Full directions
for dipping cattle to eradicate lice may be found in Farmers'
Bulletin 909 issued by the United States Department of
Agriculture.

The **horse bot** is the larva of the bot-fly (Gastrophilus equi)
(Figs. 82 and 83).   The female is woolly and gray brown in
color.   It hovers around the legs and neck, where it deposits
eggs and cements them with a special secretion to the hair.
These flies are most active in the hot summer months.   After a
time the eggs hatch and the minute larva irritate the skin,
causing the host to bite the infested part.   In this way they gain

entrance to the mouth, and eventually to the stomach. Once here they attach themselves to the mucous lining and rapidly develop into the full-grown bot. Most horses harbor a few, some as many as two or three hundred (Fig. 83).

The bots remain in the stomach for about ten months, or until May or June, sucking blood for their sustenance. Then they loosen their hold, pass along through the bowels with the ingesta, and escape in the feces. If conditions are favorable they burrow into the soil and form a pupa. Some four or six weeks are passed in this stage, after which a perfect fly emerges ready to lay eggs.
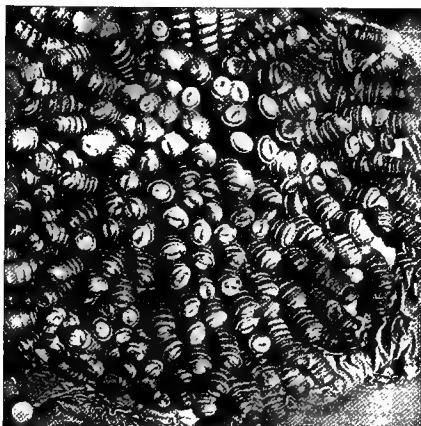
FIG. 83.—Bots attached to the lining of the horse's stomach. Full-grown larva of the Gastrophilus equi. (U. S. Dept. of Agric., Division of Entomology.)

Many different remedies have been used to free horses from bots, but all are of little or no value. Drugs strong enough to cause the bots to loosen their hold will injure the walls of the stomach, so cannot be used. Bots seldom cause serious injury, but may produce irritation and lack of thriftiness if present in large numbers by interfering with gastric secretion. In view of the fact that bots and many other internal parasites pass from the host as soon as the animals are turned out in the spring, treatment should be given in early winter to be effective. Prevention is easiest and most satisfactory. Clip off all eggs, found attached to the hair, with a sharp razor or destroy them by singeing with a flame.

The **ox warble** is an insect parasite of cattle similar in many respects to the bot of horses. The adult parasite is known as the "warble fly," and the young as "grubs," or "warbles." When mature, the fly (Hypoderma lineata) is about ½ inch long and yellowish-black in color, resembling a honey-bee. It hides in the tall grass and bushes during the greater part of the time, coming out to bother the cattle only when the weather is favorable. These flies appear during the summer months and deposit their eggs upon the hair about the heels of the cattle, thus getting the name "heel-fly." The eggs are yellowish-white in color and possess a lip-like apparatus by which they hold onto the hair. When infested cattle lick themselves the eggs are conveyed to the mouth on the tongue. The saliva causes the shell to loosen and the young grub escapes and pierces the wall of the gullet. From the gullet the little grubs find their way by various routes to the connective tissue beneath the skin covering the back. Here they develop into grubs or warbles, forming small tumors. In order to get sufficient air the parasites drill holes in the hide, which greatly reduces the value of the hide. They reach their full development during April. If the grub is removed at this time it is found to be around ¾ of an inch long and nearly ½ an inch thick. Left to themselves they will work their way through the opening in the hide and drop to the ground into which they burrow. They pass from four to six weeks in soft, moist soil and emerge as flies to lay eggs, which in turn repeat this life cycle the ensuing year. It is almost impossible entirely to prevent the appearance of the grubs, but the systematic destruction of all warbles in the backs of cattle each year will prevent their propagation very effectively and finally control the pests. The grubs may be squeezed out through their breathing holes or destroyed by applying a few drops of tincture of iodin to the opening through which they get air. The wound heals rapidly and the hide is not injured.

The **sheep grub** is the larva of a bot-fly (Œstrus ovis) smaller than either fly previously mentioned. It differs from the others in that it lays its eggs in the nostrils instead of on the hairs. The eggs hatch immediately after deposition and the little maggot-like grubs crawl up into the nose of the sheep. The grubs at once begin to work their way further and further up into the air passage, often gaining access to the air cavities in the head.

There they attach to the lining membrane by two small hooks and feed on the slimy secretion of the nasal mucous membrane. When ready to pass out for the next stage in their life cycle, they release their hold, crawl out of the air chambers, and drop to the ground.   Here they bury themselves and remain in a dormant state for forty to fifty days or longer, depending on temperature and moisture conditions.   Country slaughter houses are undoubtedly the source from which these flies are often spread. If all sheep's heads were properly destroyed, many cases of "grub in the head" would be prevented.

The sheep like the other animals has an instinctive fear of bot-flies and will hold its nose close to the ground and seek the center of the flock whenever any flies are around.   One or two flies are said to alarm a whole flock, sometimes causing a stampede. No effective method of prevention has been found.   The grubs may be removed from the heads of sheep by a surgical operation known as trephining.

The **sheep tick** (Melophagus ovinus) is a common parasite, but should be called the sheep louse, as it belongs to the insects instead of to the arachnids.   It differs from most insects in that it does not possess wings.   The adult is reddish or brownish in color, and about ¼ inch long.   It has three pairs of jointed legs instead of the four pairs characteristic of true ticks.   This is a permanent parasite, its whole life being spent on the body of one host.   It lays 8 to 10 pupæ in the fleece.   In about four weeks these hatch and release a small tick which soon becomes capable of reproduction.   The pupæ can be readily found by anyone who will separate the wool along the neck, shoulders, and belly.   All sheep are attacked, but the long wooled breeds more than the fine wooled.   At shearing season the parasite is most in evidence, lying close to the skin.   When brushed or picked off, a red irritated spot is seen where the tick has bitten the sheep and injected a little poisonous substance.   Considerable itching is produced and the sheep bite, rub, and scratch. The ticks live on the blood of the host and the yolk of the wool. At the shearing season they leave the sheep in large numbers and go to the lambs on which they find better protection.   Nearly all sheep harbor some ticks.   When they are present in large numbers they cause unthriftiness and poor condition.   Treat-

ment consists in dipping in the regulation sheep dip or kerosene emulsion immediately after shearing.

ARACHNIDS

The **mange mite of the horse** causes the very contagious disease known as mange or itch.   This parasite, like all arachnids, is so minute that it is just visible to the naked eye, and possesses four pairs of legs.   There are three genera of mange mites recognized as infesting the horse—viz., Sarcoptes, Psoroptes, and
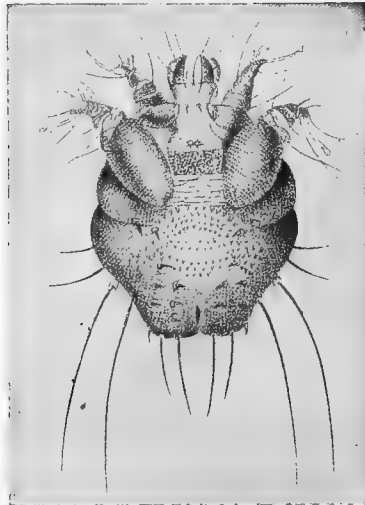
Fig. 84.—The sarcoptic mange mite of the horse.   This mite burrows into the deep layers of the skin.   (U. S. Department of Agriculture.)

Symbiotes.   Of these, the Sarcoptic mite is the most destructive (Fig. 84).   It burrows tunnels or galleries into the skin.

The symptoms of mange are intense itching, continuous rubbing, and the formation of scabs along the back and withers, where the parasites lodge just beyond the reach of the mouth and tail of the host.   The irritation seems to be most marked during hot nights.   The hair drops out and the skin thickens, cracks, and assumes a dead appearance.

To diagnose mange, scrapings should be made from the skin

and examined under a microscope. By placing the scabs on a warm, black background a strong hand lens is sufficient to demonstrate their presence, but not their genera.

The only certain way to destroy mange mites is to apply a substance over the entire surface of the body that will poison the parasites. Sulphur dioxid gas is a most effective remedy but requires a special apparatus for application. A mixture of flowers of sulphur, bicarbonate of potash, and a bland oil in equal parts has given fairly good results. Before applying this mixture, the animal should be clipped. This dressing should be left on for a week and gently rubbed in daily. The harness, currycombs, brushes, and other stable paraphernalia should be thoroughly saturated with a 20 per cent. coal tar dip solution to kill any mites which may have crawled onto them.

The **scab mite of cattle** is closely related to and resembles the mange mite of the horse. There are several genera, the commonest being the Psoroptes communis. These parasites live in colonies on the surface of the skin. Unless steps are taken to control them, serious losses result. The back, loins, and croup are first attacked because the animals cannot scratch these parts. Scabs form from the serum which oozes through the prick in the skin made by the mite to obtain food. The scabs pile up and the hair gets rough and finally drops out. The animal rubs against sharp objects to relieve the intense irritation.

Treatment consists in dipping and applying remedies that will kill the parasites without injuring the cattle. A lime-sulphur dip has been found by the United States Bureau of Animal Industry to be the most successful means of eradicating this disease. Full directions for applying the treatment are given in Farmers' Bulletin 1017.

The **scab mite of sheep** is the most destructive external parasite infesting sheep. Its attack is insidious, course rapid, and effects very injurious. This mite is known technically as Psoroptes communis.

The first indication of this disease is the tendency of infested sheep to nip at the sides where the parasites are causing irritation. This leaves the wool moistened with saliva, so that the dust will settle on the affected parts when the animals are driven along dry roads. The fleece, in case scab mites are present, appears taggy, rough, and felted. By separating the wool and

making a close examination of the skin little areas of redness and scabs will be seen. The mites may be seen by examining skin scrapings with a hand lens, or by placing this material in a warm, dry bottle. Later, after the mites have increased in number, scabs appear over a large part of the body, and the wool drops out leaving large bare areas. Emaciation and weakness soon follow, and unless assistance is given the sheep they will die in two or three months.

No time should be lost in dipping the whole flock as soon as a case of scab is found. The lime-sulphur and the tobacco juice dips give best results. The dipping solution should be warmed to the temperature of the body and the sheep dipped only on a warm day. To insure success the sheep should be redipped after ten days.

FIG. 85.—Mature Texas fever tick with pile of freshly laid eggs.

The **Texas fever tick** (Margaropus annulatus) is a parasite of cattle that is indirectly responsible for the destructive disease known as Texas or tick fever. The life history of the Texas fever tick is very interesting. The full-grown female tick is reddish-brown in color. When she becomes engorged with her host's blood, she drops to the ground. In from three to five days she has secluded herself and begins laying eggs. The eggs are ovid in shape, brown in color, covered with a varnish-like substance, and often number 4000 (Fig. 85). In warm weather and under favorable conditions the eggs hatch in about three weeks. The progeny of the eggs are so small as to be hardly visible. They have only three pairs of legs, are asexual, and resemble little spiders. They crawl over the ground or upon grass and twigs to wait until a passing animal comes along. As soon as they find a host they attach themselves and begin sucking blood. After a week they moult twice when they are provided with four pairs of legs and are sexually mature Texas fever ticks.

These little spider-like forms are really larvæ. They carry the protozoa (Piroplasma bigeminum) which cause Texas fever. The protozoa enter the red blood corpuscles of cattle which break up and liberate their coloring matter or hemoglobin. The adult ticks do not carry the protozoa from one animal to another, but

the female ticks, which develop on infected animals, transmit them to their progeny, the little spider-like larvæ, which act as the intermediate hosts for the infection.   It is through these young ticks that the actual cause of Texas fever is spread from animal to animal.

The symptoms of the disease begin in seven to ten days and are high fever, constipation followed by diarrhea, dark brown and finally red colored urine, and jaundice.   A positive diagnosis is made if the small ticks are found attached to the belly, inside of the thighs, and brisket.   Treatment is usually unsatisfactory for no specific medicine is known.   Immunity is conferred through an attack of the disease.   Prevention must include exclusion and extermination of the ticks.   Ticks are easily killed by frost so are not dangerous in the North after the first frost.

CHAPTER XX

OTHER NON-COMMUNICABLE DISEASES

In a broad sense, the non-communicable diseases include all those affections that are not transmissible either by direct or indirect contact of animals. To this group belong diseases of the digestive organs, diseases of the bones and joints, and many other affections which have been described. This chapter will be devoted to common non-communicable diseases of farm animals not described in preceding chapters.

The causes of this group of diseases are quite varied. They consist of mechanical agents, bacterial and chemical poisons, and various other substances that interfere with the proper working of body organs. The diseases they produce have accordingly been termed organic or constitutional diseases. It is evident that the course of these diseases would vary widely and their symptoms be indefinite.

AZOTURIA

Azoturia occurs when a horse, accustomed to daily work, is exercised after one or two idle days on full feed. It is characterized by coffee-colored urine and a partial or complete paralysis of the hind legs. It may occur at any time of year, but it is more common in cold weather. From 20 to 40 per cent. of the cases die, or the animal's usefulness is more or less permanently impaired by atrophy of the affected muscles. Chances of recovery are poor if the patient is unable to use the limbs after a few days.

Cause.—Azoturia is an auto-intoxication resulting from improper feeding and lack of exercise. Horses in good condition are most susceptible to it. It may be prevented with the greatest certainty by reducing the grain ration about one-third when the animal is idle and by providing daily exercise.

Symptoms.—The horse starts away from the stable in particularly good spirits.   Suddenly he lags, sweats profusely, and gets lame in one or both hind legs, which knuckle over at the fetlock joints.   Soon he has difficulty in standing and may fall, in which event he attempts to rise, but is only partially successful. Once down he rapidly becomes worse, and the symptoms are aggravated.   The urine is retained and of a thick, dark red-brown, or coffee color, and full of suspended matter.   This color is due to hemoglobin from the disintegrated red blood-corpuscles. Its presence in the urine has given the disease the name **hemoglobinuria.**   The muscles of the loins and thighs are swollen and very hard; the lining membrane of the eyelids is congested; the nostrils are dilated; the pulse at first full and bounding later becomes weak and fast.   The appetite often remains good and the horse eats hay at every opportunity, while thirst may be extreme.

Treatment.—As soon as any of the above-mentioned symptoms are noticed the horse should be stopped.   Driving even a short distance farther is likely to result in more serious trouble and lead to paralysis.   Prompt rest is absolutely essential to recovery. The harness should be removed and the patient blanketed.   It is not wise to lead him even a short distance.   The urine must be drawn off with a catheter at least twice a day, for the bladder is paralyzed.   Many different drugs have been employed, but none has proved a specific.   The attending veterinarian should be relied upon to administer the treatment which, in his judgment, appears to be best.   A gentle physic, together with ounce doses of bicarbonate of soda three times a day may be given in mild attacks.   Veterinarians use other drugs such as iodid of potash and oxalic acid as their judgment directs.   Good nursing and a soft bed to prevent injury while the patient is down are of as much importance as medicines.

BRONCHITIS

By the term bronchitis an inflammation of the bronchial tubes is understood.   It occurs in two forms—acute and chronic.   The acute form may develop into the chronic form.

Causes.—The causes are usually a sudden change in the weather, inhalation of irritating gas, smoke, chemical fumes, lung worms, and aspiration of particles of food or liquids.

22

Symptoms.—These are fever; short, dry, smothered, and painful cough in the early stages, which later has a tendency to become moist, due to exudation; wheezing or whistling sounds, detectable when the ear is placed over the trachea and sides of the chest. When exudation has taken place, moist rales or gurgling sounds can be heard very distinctly in the trachea, and a nasal discharge is present. The animal is always dull, has increased respirations and pulse, and partial or complete loss of appetite. Sometimes it is difficult to differentiate between bronchitis and pneumonia, as a severe attack of the former is frequently complicated by involvement of the lung tissue.

Treatment.—The treatment of bronchitis is not radically different from that of other diseases of the respiratory apparatus. It consists in providing rest; fresh air; hygienic surroundings; blanketing to protect the animal from draughts and sudden changes in temperature; light, easily digested food, and a liberal supply of clean drinking water, which may be kept constantly before the animal in a pail set in the manger. Half-ounce doses of nitrate of potash may be given three times daily in the drinking water until the temperature becomes normal; then Fowler's solution in half ounce doses two or three times daily will be found of marked benefit. Counterirritation in the form of mustard paste applied to the chest and covered with newspapers to protect soiling of the blanket is helpful, but severe blistering effects should be avoided. Thorough daily grooming of the body, and friction applied to the legs, with bandages to equalize the circulation, frequently have a marked beneficial effect upon the temperature and general condition of the animal. Chronic bronchitis is usually incurable.

FORAGE POISONING

Forage poisoning originates in the digestive organs, but makes its presence known by disturbances of the brain and spinal cord. In some sections of the country it is known as food or ptomain poisoning, in others as corn-stalk disease. Horses, cattle, and sheep become affected, the last less frequently. It occurs more frequently in animals having access to corn silage, shredded fodder, corn stalks, or corn cobs.

Causes.—Poisonous substances in the food appear to be the usual cause of this affection. It is believed that various molds and fungi are the exact cause, but nobody has yet succeeded in producing it by feeding immense quantities of molds to experimental animals. Graham has isolated a germ, designated *B. botulinus*, that has been shown to be the primary agent in certain outbreaks of forage poisoning. The infection is not directly communicable from animal to animal.

Symptoms.—Affected patients snow either great mental excitement or stupor, depending on the action of the bacterial toxins on the nervous tissue. The animal may become delirious, and rush about in the stall or paw, kick, and in other ways seem blind to its surroundings. In many outbreaks the primary symptoms are a staggering gait, a sleepy attitude, and dizziness. Later the animal falls to the floor, struggles to rise, but is unable to do so, and finally becomes unconscious and dies in two or three days, if not sooner.

Treatment.—Little or no results follow medical treatment once the disease is well established. Medicines to quiet the animal and eliminate the toxic substances by way of the alimentary canal are indicated. For the latter, subcutaneous administration of arecolin is highly recommended. An immediate change of feed is said to prevent the disease from attacking other animals on the farm. One attack of the disease does not confer immunity. Encouraging results have been obtained from the use of a prophylactic serum produced by hyperimmunizing horses against the B. botulinus.

GOITER

Goiter is a disease resulting in enlargement of the thyroid gland of the neck. It is widely prevalent in calves, lambs, foals, and pigs. From the fact that the neck becomes visibly enlarged in all affected animals except fat hogs, it is commonly known as **big neck.** In pigs, goiter is associated with a condition of hairlessness, hence in them it is commonly referred to as the **hairless pig malady.**

Cause.—Normally the thyroid gland forms a chemical substance containing iodin which is distributed to the various organs of the body by the blood circulating through the gland.

This compound is essential to the development of an animal. When there is need of this compound and the iodin content of the food is not sufficient to supply it, the gland enlarges to let more blood pass through in a given time.   The cause of many cases of goiter, therefore, appears to be either a failure of the intestines to absorb the iodin from the feed, or a failure of the thyroid gland to absorb and store the iodin that is in the blood.

Symptoms.—Calves, foals, and lambs affected with goiter are either born with an enlarged neck or develop one soon thereafter.   They are weak, lifeless, and fail to thrive.   Often the enlargement presses on the windpipe to such an extent that breathing is interfered with.   Hairless pigs are of normal weight and size.   They may be born alive but always die sooner or later if no hair is present.   When entirely hairless the skin is smooth and shiny, except for a few hairs around the eyes and snout. The hoofs are thin and brittle.   All pigs in the same litter are not always similarly affected; some may be hairless, others scantily-haired, and still others normal.   The sow giving birth to pigs of this kind has also been found to have an enlarged thyroid, but does not show the characteristic large neck on account of her neck being so fat and fleshy.   Goiter in the sow neither seriously affects her health, nor renders her flesh unfit for food; but unless corrected does interfere with her breeding propensity.

The thyroid gland of a normal new-born pig is about the size of a pea and contains no iodin, while that of a hairless pig is the size of a hickory nut and when dry contains about 0.2 per cent. iodin.   The gland in a normal sow varies in size, but usually is not larger than a walnut, while in a sow that has given birth to hairless pigs it may be as large as a man's fist.

Treatment.—Most feeding stuffs contain enough iodin to meet the needs of animals.   Only when an animal is incapable of absorbing sufficient iodin for body needs is treatment necessary.   At the Wisconsin Agricultural Experiment Station goiter resulting in hairless pigs has been corrected by giving the sow potassium iodid in her feed during the last sixty days of the gestation period.   Ten grams of finely pulverized potassium iodid crystals are mixed with each 100 pounds of feed.   When hogs are on pasture and get plenty of exercise the disease occurs so rarely that the remedy mentioned above need not be given.   The liberal feeding of roughage and concentrates not high in protein

during the winter months is an effective method of preventing goiter.

HEAT- AND SUNSTROKE

These affections occur from disturbances of the heat dissipation center in the brain. In their most typical form they occur while the animal is at work in the sun. Then there is more heat produced internally than when at rest, and the atmospheric temperature is often somewhat above that of the body. After the sweat-glands have become fatigued from excessive activity, so that they no longer function properly, there is a greater probability of these diseases occurring. One attack predisposes the animal to a second attack.

Causes.—As stated, the causes are direct action of the sun and excessive atmospheric temperature. Very fat hogs are especially susceptible to overheating, so should be handled very carefully in hot weather. Overcrowding in yards, shipping racks, and cars under these conditions is very dangerous.

Symptoms.—A quick, hard pulse, cutaneous circulation at low ebb, congestion of the blood in the lungs, panting, and dizziness are the usual symptoms. The temperature may be 108°F. or higher in sunstroke cases. The patient may become greatly excited and go into a perfect frenzy. This is often followed by unconsciousness, convulsions and death from respiratory arrest.

Treatment.—When an animal is overcome by heat get it into a shady place, wash out its mouth and nostrils, sponge its body, and shower its legs with cold water. Assistance must be prompt or it will be useless. Cold packs are to be constantly kept upon the head, or the water from a garden hose allowed to play gently on the head. Two ounces of aromatic spirits of ammonia or 2 ounces of sweet spirits of niter should be administered in a pint of water every two hours until relief is apparent.

HEAVES

Heaves is a chronic, non-infectious condition of difficult breathing in which the act of expiration is longer than that of inspiration. Heaves is not accompanied by fever and is not directly fatal. The chief pathologic change is confined to the lungs, the thin delicate air-sacs of which break down and lose their normal con-

tractile power.   The disease occurs oftenest in old, hard-worked horses that are greedy feeders.

Causes.—Bulky foods, indigestible foods, and foods which ferment easily all lead to over-distention of the stomach and to excessive pressure upon the diaphragm and lungs.   Dusty fodder, especially hay which has been wet during harvest, or over-ripe hay, is harmful and may induce heaves.   There is evidence that heaves is inherited or at least a tendency to it is inherited.   For example, a Clydesdale mare owned by the University of Wisconsin had a pronounced case of heaves and two of her foals developed the disease before they had reached five years of age.

Symptoms.—A peculiar, dry, droning cough is heard before the difficult breathing, later so characteristic, is noticeable. The cough is explosive in nature and soon becomes very marked; furthermore, it is aggravated by dust and is often accompanied by expulsion of gas from the rectum.   Inhalation is normal, but exhalation is labored and difficult.   This requires the patient to make a special effort to force out the air.   As a result, there occurs a "double-pumping action" of the flanks with two expulsive efforts instead of one.   This produces the so-called "heaveline" seen along the flanks of affected horses.   With exercise these symptoms are much intensified.   Disguised cases can be detected, or tests can be carried out by feeding all the dusty hay the horse will eat, then giving plenty of water and driving him briskly.

Treatment.—After the disease is once developed it is impossible to effect a cure for anatomic structures have been destroyed, so treatment can only be palliative.   It is said that horses suffering from heaves when taken to an arid country, where the disease is unknown in native horses, become serviceable and seldom are troubled thereafter.   By reducing the roughage to a minimum and increasing the concentrates accordingly it is possible to make a badly affected animal serviceable.   When grass and roots are available they may be fed in place of hay to good advantage. To relieve heaves nothing has been found so beneficial as arsenic. It is used in the form of Fowler's solution.   The remedy may be given in $\frac{1}{2}$-ounce doses three times a day, with a tablespoon of Carlsbad salts on the grain.   When continued over a long period,

uh's treatment affords remarkable relief.   Dry feed should always be dampened before it is fed.

LIGHTNING AND ELECTRIC STROKE

By lightning or electric stroke is understood an injury to nerve tissue produced by powerful currents of electricity.   In some instances no pathological change is found in the tissue, the disturbance being altogether functional.

Lightning stroke commonly occurs in the open country, animals on pasture being victims.   In the city horses occasionally come in contact with high-tension wires which have fallen upon the street.   During the summer season thousands of animals are killed or injured by lightning on the farms of this country.

Symptoms.—Usually a lightning stroke kills the animal instantly or in a few minutes.   In other cases the animal appears stunned from the stroke, but soon regains consciousness and normal condition.   In a few instances, however, the patient is left for a time with irregular gait, and weakness of the hind parts.   It may show forced movements, and appear stupid and dull.   Usually recovery occurs after a few days or weeks.   In some cases partial paralysis of individual nerves persists and recovery then may take one or two months.   Horses are sometimes left permanently blind or deaf.

In case death occurs suddenly from lightning stroke the rectum of the animal will be protruded and the diaphragm ruptured. These changes are brought about by the sudden and complete contraction of the muscles, especially those of the body walls, which forcibly compress the viscera.

Treatment.—If the patients remain down good bedding should be provided.   To assist the return to consciousness excitants (alcohol, ether, camphor, caffein, skin rubbing) may be tried.

LUMP JAW

Lump jaw is the common name and actinomycosis the scientific name of a chronic, non-communicable disease affecting the jaws of cattle.   In hogs the udder is frequently the seat of infection.

Cause.—An infectious agent known as the ray fungus is the cause of lump jaw.   This microörganism has been discovered on

barley awns, oat stubble, and various grasses, but has never actually been found growing outside the animal body.

Symptoms.—A hard, slowly developing, tumor-like swelling occurring on the jaw is the only symptom of importance during the early stages of the disease (Fig. 86). The bunch feels as if it were attached to the bone. In the later stages the roots of the teeth in the affected part become ulcerated. This causes difficulty in mastication and profuse slobbering of saliva. Pro-

FIG. 86.—Lump jaw or actinomycosis of Ayrshire bull.

gressive emaciation occurs from inability of the animal to masticate its food properly.

Treatment.—When begun early, treatment with potassium iodid internally and tincture of iodin or iodin petroxalin externally give good results. The dose of potassium iodid is 2 to 4 drams once a day until symptoms of iodin poisoning appear (watery eyes, loss of hair and appetite, scurvy skin and general weakness). The medicine must then be discontinued for a week. Laxative feeds are recommended as a preventive of constipation during the period when iodin is being given. This drug should

not be administered to cows that are milking heavily or due to calve within two months. Unless very valuable for breeding purposes, it will be best to fatten affected cattle and sell them for beef. When such animals reach the stock yards they are promptly tagged and subjected to a rigid postmortem examination. If the disease is localized in the head, the carcass is passed as fit for food, but the head including the tongue is always condemned. This is a certain way of securing practically the full value of the animal.

LYMPHANGITIS

"Monday morning disease" and "big leg" are other names for this disease of horses. It is characterized by a suddenly appearing pronounced swelling and lameness. One hind leg most commonly is affected. The lymphatics appear to be the structures affected.

Causes.—There is some difference in opinion as to the cause. When an abrasion can be found in the skin through which infection has had an opportunity to enter, it is reasonable to attribute the disease to bacterial invasion. At other times unwonted idleness on full feed seems to be the determining cause. Heavy horses are more likely to acquire lymphangitis than are driving horses.

Symptoms.—The swelling progresses rapidly and soon involves the entire leg. Pain is present and is shown by the patient holding the leg in a position to get most relief. When the lymph-glands situated on the inside of the thigh are pressed, great sensitiveness is exhibited. Pressure over the swollen part with the finger-tips leaves well-marked pits. Fever as high as 105° or 106°F., with its usual accompaniments, is present.

Treatment.—Bathe the leg for half-hour periods three times each twenty-four hours with warm water, rub dry, and apply soap liniment with friction to stimulate circulation. Half to one ounce doses of saltpeter are given three times a day. The bowels must be kept loose by giving laxative feeds. Where gorging with feed has induced the attack, a pint to a quart of raw linseed oil may be given as one dose. When these directions are closely followed recovery is rapid, but attacks are apt to recur and lead to a permanent enlargement known as "elephant leg."

MILK FEVER

Milk fever is a non-contagious, non-febrile disease of cows occurring at calving time. Heavy milk producers in good flesh are most susceptible.

Causes.—Several theories have been advanced to account for the cause of milk fever. Some veterinarians hold that the blood congests in the uterus and udder and leads to anemia of the brain and spinal cord. Others think it is an autointoxication due to absorption of poisons generated in the collostrum in

FIG. 87.—Cow in the last stage of milk fever completely paralyzed. Recovery was rapid and complete after the air treatment was administered.

the udder. Predisposing causes are heavy feeding and lack of exercise before calving.

Symptoms.—The symptoms of milk fever start with excitement and end in complete loss of consciousness, the animal going through much the same stages as it does when given a general anesthetic, such as ether or chloroform. The patient has a wild look in the eye, switches her tail, trembles, weakens, staggers, lies or falls down, tries to rise but is unable to do so on account

of paralysis of the muscles. She then rapidly loses all sensation and passes into a state of unconsciousness or coma with her head tucked into the right flank. The breathing is deep and slow. Later the cow stretches out flat on her side (Fig. 87). The temperature is seldom elevated, hence the name milk fever conveys the wrong impression of the disease. For this reason the scientific term parturient paresis, meaning a paralysis occurring at parturition, is preferable.

Treatment.—A simple method of treatment which usually is successful, if given early, consists in the inflation or distention of the udder with air, gas, or fluid. If air is used it is pumped through absorbent cotton to remove dust particles and germs and thence into each quarter by means of a milking tube attached to a rubber tube. In an emergency a bicycle pump may be utilized for this purpose instead of a specially designed apparatus. Precautions must be taken to have the milking tube sterilized by boiling it for ten minutes. The end of the teat should be disinfected before the tube is inserted. To prevent escape of the air, the end of the teat is repeatedly pushed into itself until it stays of its own accord. Pieces of tape or rubber bands should never be tied around the teat for this purpose, as they may cause trouble. In most cases the above treatment will restore consciousness within a short time and soon after the cow will be up and ready to eat. The after treatment consists in good nursing and small feeds of a laxative ration.

As soon as the udder has been inflated, sacks stuffed with straw should be placed under the cow's shoulder and side to prop her up. This is to prevent the passage of saliva down the trachea into the lungs and to take pressure off the paunch, in which gas has a tendency to collect and to cause bloating. Instead of waiting for the cow to arise voluntarily, urge her to do so after she is fairly bright. When she makes a good attempt to get up, assist her by lifting on the tail. Support her until she can stand alone, but do not permit her to move.

MOON-BLINDNESS

The name by which this affection is properly known is periodic ophthalmia. The disease occurs only in horses and is characterized by periodically occurring attacks of inflammation of the eye. Eventually the animal becomes blind.

Cause.—The exact cause is not known. The disease is generally considered hereditary, but by many is believed to be due to a specific germ. In many countries affected stallions are disqualified by law as unfit for public service.

Symptoms.—The first attacks are shorter in duration than later ones. An interval of several weeks intervenes between attacks. A diffuse inflammation of all parts of the eye occurs, with a profuse flow of tears, swollen lids, and great sensitiveness to light. With each succeeding attack the normally transparent structures become gradually clouded and opaque, until permanent blindness results. In old cases the eyeball atrophies and recedes into its socket. This causes the upper lid to buckle near the center and to form what appears to be a third canthus.

Treatment.—Place the animal in a darkened stall at once. Cover the eye with a soft cloth or compress to be kept wet with a saturated solution of boric acid. Once the lens of the eye loses its transparency nothing can be done to restore the sight.

MUSCULAR RHEUMATISM

Muscular rheumatism is a non-infectious disease of the muscles of rather rare occurrence in horses and cattle. It may be either acute or chronic in its course.

Causes.—The causes are unknown. Cold and dampness are predisposing factors. It seems that the direct cause is either an infection or auto-intoxication.

Symptoms.—The symptoms are a shifting lameness, which develops suddenly after a previous cooling, pain evinced on palpation of the affected parts, and a mild fever.

Treatment.—This consists in the external application of moist warmth, massage, and liniment containing spirits of camphor. Salicylate of soda administered internally in two dram doses two or three times daily, according to the severity of the case, usually proves beneficial.

PLEURISY

Pleuritis is inflammation of the pleura, the serous membrane that covers the lungs and lines the thorax and anterior surface of the diaphragm. It occurs in horses and all other domestic animals, but is usually secondary to some other disease. The changes either result in an effusion of serous fluid into the pleural

cavity, or so roughen the smooth contact surfaces of the pleura that friction is produced with each respiration.

Causes.—There is a prevailing idea that pleurisy is usually caused by exposure to cold draughts, especially after the animal has been very hot and sweaty. It appears, however, more frequently after a disease such as pneumonia, glanders, or tuberculosis has paved the way. Puncture wounds of the thorax always cause pleurisy.

Symptoms.—If the case is seen early, pain and chills are the noticeable symptoms. The temperature ranges from 105° to 106°F. and the pulse is quickened. Breathing is altered, in that an effort is made to restrict movement of the chest wall. This results in additional work for the abdominal muscles, and the typical "pleuritic ridge," extending from the lower ends of the false ribs to the point of the hip becomes a marked symptom. Horses persistently stand, while cattle lie down when affected with pleurisy or pneumonia.

Generally speaking, the course of pleurisy is slow. Recovery is not always complete for adhesions occur between the pleura covering the lungs and that lining the walls of the thorax. This results in permanent interference with the normal expansion and contraction of these organs and leaves the horse "defective in the wind."

Treatment.—This is similar to that mentioned for pneumonia. If pain is so great as to cause distress in breathing, $\frac{1}{2}$ ounce of chloral hydrate may be given. If much fluid has accumulated in the thorax, it should be drawn off by means of a trocar and canula.

PNEUMONIA

Any inflammatory condition of the lungs is spoken of as pneumonia. In this, as in all forms of inflammation, more blood is brought to the inflamed tissues than normally. This results in a part of the fluid portion of the blood passing into the minute air-sacs of the lungs. The presence of this exudate reduces the capacity of the lungs to deliver oxygen to the blood and remove carbon dioxid from it. Later the fluid thickens by the addition of mucus and fibrin, forming a thick phlegm. This causes the involved portion of the lung to become a solid mass that resembles liver, so it is said to be hepatized.

Veterinarians recognize several different types of pneumonia. When it is the result of a perforation from the outside it is spoken of as "traumatic pneumonia;" when an entire lobe of one lung is affected, "lobar pneumonia;" when both lungs are involved, "double pneumonia;" when due to aspiration of foreign substances which cause death of the tissues, "gangrenous pneumonia."

The course of pneumonia is rapid in all types except the gangrenous, which may run for several weeks. In most cases that are destined to terminate favorably the temperature falls abruptly between the seventh and eleventh days.

Causes.—There are many causes of pneumonia, though usually the disease can be traced to exposure to cold drafts or winds, more especially after the patient has sweated profusely and is fatigued. Not infrequently it is due to direct irritation from foreign substances such as smoke, dust, lung-worms, and aspiration of medicines that have been administered through the nostrils. In the ox it is frequently caused by the perforation of nails or pieces of wire through the stomach wall and diaphragm into the lungs. It may follow attacks of influenza, strangles, and other infectious diseases. With our present knowledge it is impossible to attribute pneumonia of farm animals to a specific microörganism, although it seems probable that most cases, if not directly due to the presence of microörganisms, are sooner or later infected by them.

Symptoms.—At the outset the symptoms are not marked, so they are either overlooked by the attendant or not regarded as indicative of serious trouble. Medical attention rarely is sought before the animal develops difficulty in breathing, a fever of 104° to 105°F., a deep moist cough, and loss of appetite. By this time the horse refuses to lie down and stands with the elbows turned out, the nostrils dilated to permit easier breathing, and the nose held so as to get the freshest air. Often a rusty-colored nasal discharge will appear after a few days. The odor of the expired air is very putrid in gangrenous pneumonia.

Treatment.—When pneumonia develops it should be viewed as a most serious disease requiring the best medical treatment obtainable. Good nursing and attention to the hygiene and feed of the patient are more important than medicines. It is essential that absolute physical rest be provided, if the fight against death is to be won. A plentiful supply of pure air, even if it is cold, is

of great importance.   It will not irritate the lungs nearly so much as warm, impure air, provided the body is warmly protected by a woolen blanket and the legs are wrapped with bandages.   In the early stages it is desirable to induce sweating for one to two hours.   This is best accomplished with a heavy woolen blanket and 5 grains of pilocarpin administered hypodermically.   Later it may be necessary for the veterinarian to give fluid extract of digitalis to regulate the heart.   When the patient is very weak and after the fever has commenced to fall, stimulants such as strychnin and alcohol may be given.   On no account should an animal with pneumonia be drenched, as the fluid is apt to "go down the wrong way" and cause serious trouble.   Instead, give medicines in the form of a paste which can be smeared on the tongue or teeth.   Whatever drugs are used should be given only under the doctor's direction.   Throughout the treatment remember that one should not let regard for inconvenience or expense deter him from giving the patient every possible help.

ROARING

Roaring is a chronic disease of the air-passages of the horse in which a noise resembling a whistle or roar is produced at each forced inspiration.   The fact that it is considered hereditary has led to the disqualification of afflicted stallions for public service in many states.

Cause.—Some obstruction to the free passage of air is the cause. In the usual form there is found a paralysis and wasting away of one of the groups of muscles which move a part of the larynx. Often a more or less serious sickness precedes the appearance of this condition.

Symptoms.—The chief symptom is a roaring or whistling sound following a brisk trot or heavy work.   This sound in severe cases may be heard at some distance.

Treatment.—Little hope can be entertained for spontaneous recovery.   Within recent years a surgical operation has been perfected which relieves about 70 per cent. of the horses operated upon when it is properly performed, so that permanent improvement occurs, no matter what kind of work the animals are required to do.

CHAPTER XXI

SOME COMMUNICABLE DISEASES[1]

Communicable diseases are also known as infectious, contagious, and preventable. They are infectious from the fact that each is produced by the entrance into the body of a specific or single disease-producing or infectious microörganism to which the body reacts by showing characteristic symptoms and lesions. They are contagious because they pass to other animals of the same or other susceptible species by direct contact. They are preventable because it is possible to prevent their spread by stopping the transmission of the microörganisms to other animals.

As a rule, the bacteria of these diseases do not produce typical wound infections following introduction into the tissues. Although our present methods of study have failed to discover the germ of a few communicable diseases, it is certain that some form of germ life is responsible for each. The term **virus** is employed to designate the cause of those infectious diseases of which the organism is so small that it cannot be seen with the microscope and will pass through a very fine filter.

As with the non-communicable diseases, secondary infections are often implanted upon or associated with the primary causes of communicable maladies. Most of the secondary infections are caused by pus-producing organisms. In many cases these germs gain admission to the blood-stream and are carried to all parts of the body. When they reach an organ having a weak resistance, they lodge, immediately start to multiply, and cause serious interference with its functions, complicating the original disturbance, rendering diagnosis more difficult, and hastening death.

The time which elapses between the exposure of the animal to infection and the appearance of visible symptoms of the disease is called the **period of incubation.** It varies from a few days in very acute diseases to several weeks in chronic affections. Usually

[1] See appendix for outline for the study of the communicable diseases.

352

the incubation period of a given disease is the same for animals of the same species when subjected to the same mode of infection.

ANTHRAX

Anthrax is one of the most widespread diseases of a communicable nature. It usually occurs as a sporadic disease in nearly all warm-blooded animals and especially in cattle. The disease in man chiefly occurs among those working with hides, wool, or meat of infected animals. The period of incubation is from one to five days. The mortality is variable, depending upon the virulence of the outbreak, and runs from 50 to 95 per cent.

Cause.—This infection is caused by the anthrax bacillus, which is found in the soil, on forage, and in stagnant water. It forms spores that are very resistant. A small quantity of dried soil, which had been kept for eighteen years in a laboratory, has been found capable of producing death when inoculated into a rabbit. The germ gains access to the body through the digestive or respiratory tracts or through wounds in the skin. Infection from the soil is a more frequent source of the disease than contact with infected animals. The disease is communicable during the febrile stage and until the lesions have ceased discharging. Infected soil, water, hair, hides, etc. may remain infective for many months, unless disinfected.

Symptoms.—The most characteristic features of anthrax are the suddenness of its appearance, high fever, great prostration, and fatality. When the skin is affected carbuncles develop. If the animal recovers, the affected skin and subcutaneous tissue slough away leaving an open wound that heals slowly.

A postmortem examination shows tar-like blood, greatly enlarged spleen, congested lymphatic glands, and blood extravasations throughout the body. The disease is identified by a microscopic examination of the blood, in which the large rod-shaped bacilli are found in great numbers. Animal inoculations and cultural studies are used to make the diagnosis positive.

Treatment.—As treatment of affected animals is usually not satisfactory, much importance attaches to the prevention of this disease. In addition to precautions for guarding the food and water against contamination there are a number of methods of producing immunity. The most generally used method was

23

developed by Pasteur. It consists in two subcutaneous injections of vaccine, prepared from attenuated cultures of the bacillus of anthrax, given at an interval of twelve or fourteen days. The inoculations must be repeated each year to keep the immunity of the animal at a point sufficiently high to withstand natural infections.

The blood-serum of animals rendered hyperimmune to anthrax has been used both as a prophylactic and therapeutic agent. When used in conjunction with the vaccine the chances for perfect immunity without loss are greatly increased.

Infected herds should be quarantined, infected animals isolated, and all milk or other products withheld from sale until danger from disseminating the disease by them is past.

BLACKLEG

Blackleg is a highly contagious disease affecting cattle between the ages of six and twenty-four months. It is readily communicated from animal to animal and is usually fatal after a course of twelve to thirty-six hours. The period of incubation is three to five days.

Cause.—An organism known as the blackleg bacillus is the sole cause. This agent gains entrance into the body through abrasions of the skin. It is a gas-producing organism that develops only in the absence of oxygen; therefore the wound in the skin must be small, otherwise enough oxygen is admitted to prevent the germ from multiplying. The source of the infection is another animal sick or dead from the disease. The mode of transmission is by direct contact with cases or articles freshly contaminated with discharges.

Symptoms.—The first symptoms are high fever, loss of appetite, suspension of cud chewing, and great depression. Respirations increase, the movements become stiff and painful, and the visible mucous membranes dark red to purple in color. The most characteristic symptom is the appearance of swellings over the heavily muscled parts of the body such as the thighs and shoulders. These swellings are at first small but increase rapidly in size and may cover a large portion of the body. When the skin over one of these swellings is stroked with the palm of the hand a distinct crackling is heard and felt. This is due to

the gas produced by the blackleg germs in the tissues. The tumor is cool to the touch, non-sensitive, and is found to contain a frothy, bloody fluid with a peculiar sweetish odor. Guinea pig inoculation is the most reliable means of establishing a diagnosis.

Treatment.—Remedial treatment is useless. Preventive treatment by means of a vaccine is very effective. The method of vaccination most largely used consists in inoculating healthy susceptible cattle with a vaccine composed of attenuated spores of the blackleg organism. The losses following vaccination are less than $\frac{1}{2}$ of 1 per cent.

CONTAGIOUS ABORTION

The contagious form of abortion in cattle is a chronic, insidious disease that confines its ravages largely to the organs of reproduction. It is the most widespread of all diseases to which cattle are subject. Mares also suffer from this disease to such an extent that in some sections the raising of foals is unprofitable.

Cause.—A specific germ has been discovered for each animal species. In cattle the abortion bacillus of Bang is the cause. This microörganism seems to require fetal tissues or milk for existence, so is found almost exclusively in the pregnant uterus or udder. Heifers are more likely to become infected than cows because they have less resistance. The bull seldom acquires the disease. Recent experiments point to the cow which has aborted, rather than the bull, as the chief means of spreading the abortion germs. Although most cows that become infected abort sooner or later, a few appear to have a tolerance for the germs and calve normally.

Symptoms.—During the early months of pregnancy no symptoms are evident. Impending abortion is indicated by swelling of the udder, congestion of the external genitals, and a discharge from the vagina. The fetus is born dead or so weak that it often dies within a few hours (Fig. 88). Retention of the afterbirth is a frequent complication. An aborting cow gives less milk than she would if normal and is likely to abort in the next gestation period unless given proper treatment.

Certain animals become "carriers" of the germs, distributing
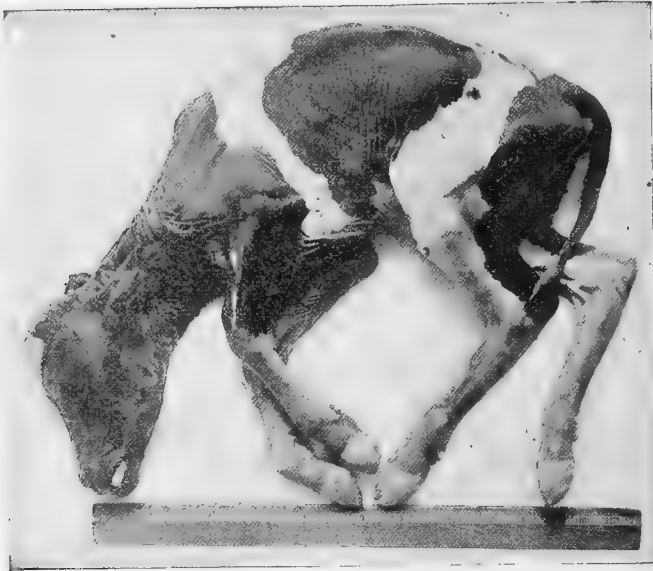
Fig. 88.—A fetal calf aborted at the seventh month of gestation as a result of the cow being infected with the abortion bacilli.

Fig. 89.—This cow is immune to contagious abortion although a "carrier" of the disease.   She aborted three calves, then dropped three normal calves.

them for years (Fig. 89). To detect these carrier cases, as well as others of more recent origin, recourse may be had to blood tests. These tests show the presence or absence of antibodies produced as a result of infection with the abortion germs, but do not tell whether the germs are actually present.

Treatment.—Immediately after an animal aborts the soiled litter, fetus, and fetal membranes should be disposed of in a sanitary manner. The stable floor is then to be disinfected with a strong liquid disinfectant. If the afterbirth is retained, the womb must be douched with blood-warm, 1 per cent. salt solution, otherwise pus is likely to accumulate and prevent conception. In other words, the cow will become a non-breeder or is barren if not given proper care after aborting. At present investigators are urging the use of a vaccine, composed of live abortion bacilli, as a means of conferring immunity. This product is injected subcutaneously in 30 c.c. doses at least two months before the animal is bred. A bacterin containing millions of killed abortion bacilli per cubic centimeter has been widely used but the results obtained do not warrant recommending it.

DOURINE

Dourine is an infectious disease of the horse and ass transmitted by copulation. It runs a course of from nine months to two years and is fatal in about 70 per cent. of the cases. Until 1912 and 1913 no serious outbreak had occurred in the United States since 1901. In June 1912, an outbreak of the disease occurred in Montana. It proved to be so extensive that on February 23, 1914, Congress granted $100,000, or as much thereof as would be needed, to investigate, treat, and eradicate it.

Cause.—It is caused by a protozoan parasite (Trypanosoma equiperdum) which is found as an actively motile microörganism in the blood. The period of communicability of this disease may extend throughout the life of the infected animal.

Symptoms.—There are many variations in the symptoms of dourine, so it is impossible to describe a single case and at the same time convey a good idea of the disease. Among the usual symptoms in the stallion are an irritation and swelling about the penis and soreness of the glands in the groin. Soon vesicles appear and break, leaving irregular raw ulcers, which

heal rapidly but leave permanent white scars. In the mare somewhat similar symptoms occur. A laboratory blood test is necessary to clinch the diagnosis in the early stages of the disease.

Treatment.—Medical treatment is of little benefit. Infected horses must be excluded from breeding, and had best be immediately destroyed to prevent communicating the disease to others of their kind.

FOOT-AND-MOUTH DISEASE

A highly communicable disease of cloven-footed animals characterized by fever and the appearance of "water blisters" or

FIG. 90.—Head of cow affected with foot-and-mouth disease showing saliva drooling from the mouth.   (B. A. I.)

vesicles.   The mortality ranges from 1 to 3 per cent. in ordinary cases.

Cause.—No specific germ has been discovered, but there is no question that foot-and-mouth disease is caused by a virus, for it can be produced experimentally by inoculating calves with saliva from a sick animal.

Symptoms.—In three to six days after exposure, the following symptoms appear: a moderate fever; the eruption of small blisters containing a straw-colored fluid in the mouth, between the claws of the feet, and in severe cases on the udder and teats. After the disease becomes well established, the lesions in the mouth make eating difficult and stimulate a profuse flow of saliva, which hangs from the lips in strings (Fig. 90). When the feet are severely affected, the animal lies down much of the time. Caked udder and abortion are secondary, or complicating, diseases that reduce the productivity to such an extent that the losses may amount to 20 or 30 per cent. of the value of affected cows. In hogs the lesions are largely confined to the feet so lameness is the most prominent symptom in these animals. An early diagnosis is especially necessary in the first cases of an outbreak in order to bring the disease under control. The method usually followed is the inoculation of calves with fluid from the small blisters of supposedly infected animals.

Treatment.—In the United States no attempt is made to treat animals known to be affected with or exposed to foot-and-mouth disease. Instead, they are slaughtered and their bodies disposed of under the direction of the live stock sanitary authorities. This method of handling outbreaks has been successful in stamping out the disease every time it has appeared. The last outbreak, which occurred in 1914, was widespread but was prevented from getting a permanent foothold in this country by the method of control just described. An attempt has been made to produce a serum for immunizing cattle, but results from its use do not appear to have been satisfactory.

FOOT ROT

Cattle and sheep occasionally suffer from a contagious foot rot. Unless steps are taken to control the disease, it may spread to many animals in the herd or flock and result in death from absorption of toxic products.

Cause.—The organism responsible for most outbreaks of foot rot is the Bacillus necrophorus, the same germ that causes necrobacillosis of pigs.

Symptoms.—Affected animals become lame, develop a hot and painful swelling around the hoof, lose their appetite, get

thin, have a rise of temperature, and finally die. Often fistulous tracts extend under the horny layer as well as in the softer tissues of the feet and legs.

Treatment.—In the first place the necrotic tissue should be trimmed away and the fistulous tracts drained, then a disinfectant applied to destroy the germs. An effective remedy for cattle is pure pine tar. The latter may be kept in contact with the diseased areas by a bandage passed between the claws, wound around the pastern, and tied.

GLANDERS

Glanders is an infectious and contagious disease affecting primarily the respiratory organs of horses and mules. It is communi-
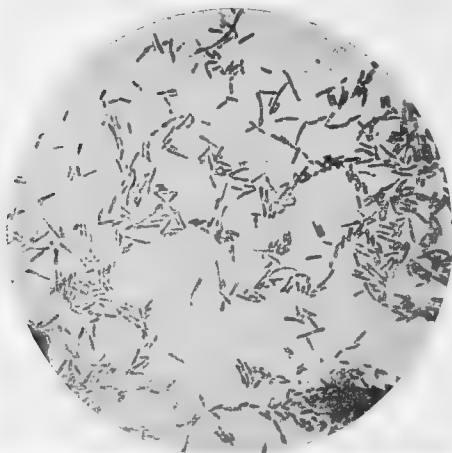
FIG. 91.—The glanders bacillus (Bacillus mallei). Pure culture from glycerin agar. Carbolfuchsin stain × 1000. (Fränkel and Pfeifer.)

cable to man. When the lymph glands just beneath the skin are the seat of infection, the term "farcy" is used to designate the disease. It is more likely to attack animals in a rundown condition than others, as their resistance is weakened. In these and in mules it is usually fatal. Depending upon the manner of exposure and the virulence of the particular strain of Bacillus mallei, the incubation period varies from one to two weeks.

Cause.—The Bacillus mallei is the cause of glanders (Fig. 91). This organism gains entrance to the body through wounds of the skin. The secretions and excretions of diseased animals are the source of infection. The mode of transmission is by contaminated mangers or feed, drinking utensils or water, harness or halter, curry comb or brush.

Symptoms.—The subacute or chronic form of the disease is oftenest seen in the horse. It is evidenced by a sticky nasal
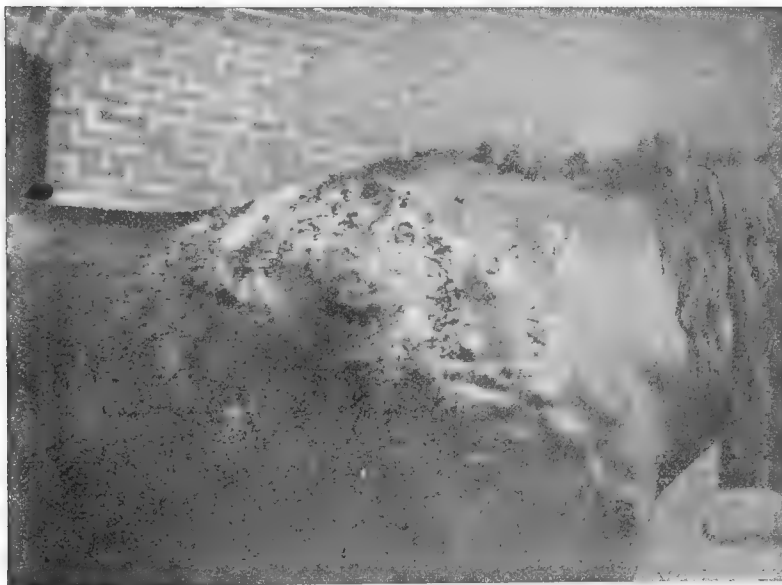
FIG. 92.—Glanders or farcy of the skin. The lesions of farcy here shown are found only in advanced cases. (U. S. Department of Agriculture.)

discharge, congestion of the nasal mucosa, cough, intermittent fever, rapid loss of condition, and swelling of the submaxillary lymph-glands, which become hard and sensitive. Farcy buds occur in advanced cases in the skin of the inner side of the hind leg, shoulder, neck, and breast (Fig. 92). These quickly suppurate and leave discharging ulcers. Ulcers also appear in the nose; when they heal, characteristic star-shaped scars are left to mark their location.

A positive diagnosis is made by inoculating the suspect with a small amount of mallein, either subcutaneously or into the eye. Mallein is prepared by sterilizing cultures of B. mallei, that have grown for about a month, by means of heat. The dead culture is then passed through a fine filter and the filtrate constitutes mallein. Tests on the blood-serum may be made in doubtful cases to corroborate the diagnosis. Guinea pigs injected with virulent material succumb in eight to ten days.

Treatment.—This is never warranted, first, because few recoveries follow, and, secondly, because once a horse becomes infected he is a source of danger to others with which he comes in contact, even after all visible symptoms of the disease have disappeared; therefore, it is always advisable immediately to destroy all affected animals. It is the duty of every person who has reason to suspect glanders in any animal under his control immediately to report the fact to the local board of health and to the state veterinary officer.

HEMORRHAGIC SEPTICEMIA

Hemorrhagic septicemia is a communicable disease of cattle, sheep, and swine that runs a short course and often ends in death. In swine the affection is known as swine plague. The period of incubation seems to be very short. The method of infection is not known.

Cause.—The causal organism stains at the poles, hence its name Bacillus bipolaris septicus. Different types of the organism exist for animals of different species. The organism can be isolated by inoculating rabbits with fresh tissues from animals affected with the disease. As the organism dies soon after its host dies, attempts to isolate it from any but strictly fresh tissues fail.

Symptoms.—Affected animals show one or more of the following symptoms: refuse feed; exhibit a fever up to 107°F.; develop swellings about the throat and brisket; have difficulty in breathing. In the intestinal form the feces are bloody and the animals may show colicky pains. The usual lesions found after death are: swollen, injected lymph glands; hemorrhages beneath the skin and within the walls of the intestines; bloody points under the serous membranes of the heart, diaphragm and other organs.

Treatment.—Medicines are unavailing once the disease is well advanced. Therefore, efforts should be directed toward preventing its spread to other animals. This is done by removing all unaffected animals to fresh quarters and by injecting them with a bacterin composed of killed cultures of the hemorrhagic septicemia germs. Reports from the use of this bacterin are contradictory and leave some doubt as to its efficiency. Recently a specific antihemorrhagic septicemia serum, made by hyperimmunizing animals against the germs, has been made available. As yet not enough animals have been treated with this product to justify a conclusion as to its merits. However, this method of conferring immunity is logical, especially for animals in infected herds.

HOG CHOLERA

Hog cholera is a preventable disease of swine that frequently sweeps over the hog raising districts as an epizootic leaving millions of dead animals in its wake. Swine of all ages and breeds are susceptible. The disease runs either an acute or chronic course. The first cases in an outbreak are usually of short duration and succumb quickly; in subsequent cases the animals are sick longer and may recover.

Cause.—A form of life so extremely minute that it is capable of passing through the pores of the finest porcelain filter is the cause of hog cholera; accordingly, it belongs to the group of disease-producing agents known as filterable viruses. The virus of hog cholera can be propagated only in the blood of susceptible hogs. The period of incubation is from five to ten days.

Symptoms.—Acute hog cholera manifests itself differently in different animals, but in typical cases the following symptoms may be observed: loss of appetite, constipation followed by diarrhea, chills, fever, coughing, gumming of eyelids with a sticky secretion, stiffness, weakness, and paralysis. After death, the skin along the belly and between the fore legs is reddened, the lymph glands congested, the kidneys spotted with little hemorrhages (Fig. 93), and the lungs often affected with pneumonia.

Treatment.—There is no cure for hog cholera, but a very effective preventive having some curative value has been perfected in the form of anti-hog-cholera serum. This serum is obtained

from the blood of hogs rendered hyperimmune to the disease by several large doses of hog cholera virus inoculated at weekly intervals.

Anti-hog-cholera serum when injected alone confers a temporary or passive immunity that lasts from six to ten weeks. If virus is injected simultaneously with the serum, a mild form of the
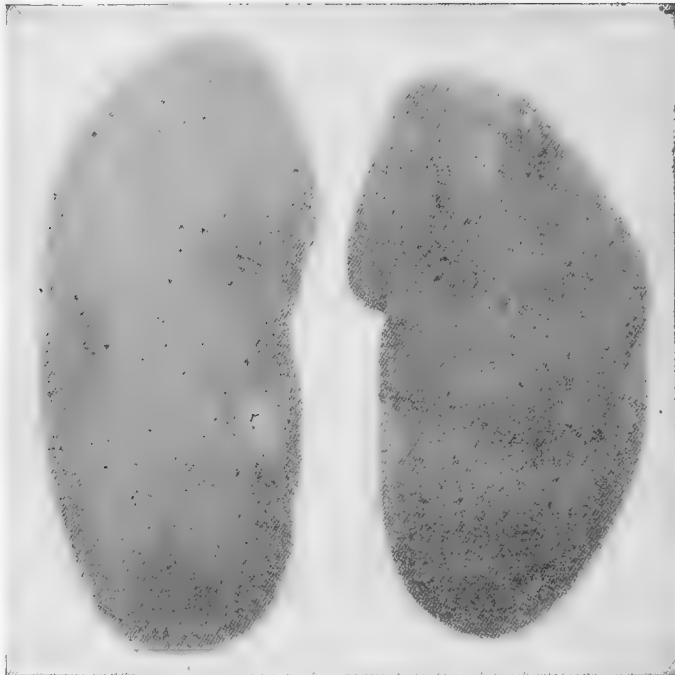
Fig. 93.—Kidneys from a cholera-infected hog showing the characteristic small red dots which give a "turkey egg" appearance.

disease is set up from which the animal quickly recovers and is rendered immune for at least a year and in many cases for life.

The serum is injected under the skin at any convenient place, but some distance from where the virus is introduced to prevent the two fluids from mechanically mixing after injection, which would cause them to neutralize each other and be ineffective. The skin at the point of injection should be cleansed with soap and

warm water and disinfected with tincture of iodin, **4 per cent.** carbolic acid solution, or other suitable disinfectant. Pigs may be restrained for the operation by holding them with the hands; large hogs by snubbing to a post (Fig. 94).
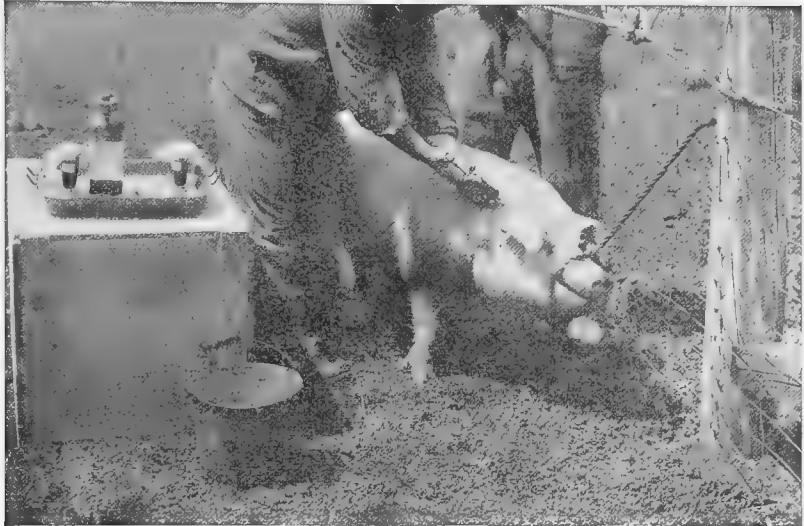
FIG. 94.—Method of restraining and vaccinating a large hog.

INFLUENZA

Influenza is a disease of horses that oftenest occurs when these animals are brought together in large numbers for shipment, hence the common name "shipping fever." From its resemblance to epidemic influenza of man, it has been called "the flu." It usually runs a course of about one week, has a mortality of 5 per cent. and is complicated by lung, bowel, and other affections that are fatal or greatly impair the usefulness of the horse.

Cause.—Although a number of different organisms have been isolated from infected animals, none has yet been proved to be the sole cause. There is no question that it is of microbial origin.

Symptoms.—The symptoms during the incubation period, which lasts from one to three days, are chills, fever up to 104° or 105°F., depression, and loss of appetite. Some attacks are charac-

terized by acute swelling and redness of the mucous membranes of the eyelids; these cases are called "pink eye." Not infrequently swellings occur in the legs and along the belly.

Treatment.—This should be prompt and started under the direction of a veterinarian at the very onset of the disease. Laxative foods must be provided and every precaution taken to protect the patient from drafts and exposure. When the body temperature runs above 105°F., remedies to reduce it are indicated. Potassium iodid is useful as a general eliminating agent. Symptoms are treated as they develop, depending upon the organs from which they arise. A bacterin has been used as a preventive and curative agent, but it is not specific, so does not give perfect results.

NAVEL ILL

Navel infection is so frequently associated with infection of the joints that the two affections are often described under the common term navel and joint disease. This is an acute infection generally characterized by the formation of pus in the joints. In foals it is fatal in about 50 per cent. of the cases. A large proportion of the animals that survive are left with deformed joints. If the disease does not appear until the suckling is several weeks old the chances of recovery are better.

Cause.—In foals and lambs the cause appears to be an organism of the colon-typhoid group, which is carried by the bloodstream from the navel where the infection takes place, to the joints, lungs, and liver. From the fact that pus is formed in the joints, it would appear that pyogenic bacteria are associated with the cause of the disease.

Symptoms.—These appear twenty-four to forty-eight hours after infection has occurred. The foal refuses to suck and has a fever. The joints become hot and swollen, and the young animal moves with difficulty or lies stretched out flat on its side. There may be no signs of inflammation at the navel; in other cases a considerable amount of pus is present (Fig. 95).

Treatment.—Preventive treatment is of more importance than curative treatment. It can be accomplished by disinfecting the navel immediately after the navel cord breaks, and twice a day afterward until it dries up, drops off, and no raw spot remains. A shallow, wide-mouthed bottle should be nearly filled with a

1 : 500 solution of corrosive sublimate or tincture of iodin and the navel stump immersed in it. To keep the disinfectant from blistering the foal's belly, smear vaseline on the skin around the navel before applying the solution. A dusting powder that would dry up the cord is useful. Death may often be averted by promptly opening and disinfecting the abscesses wherever found. Stimulants to sustain the heart and medicine to control digestive disorders, frequent complications, must be provided.

Fig. 95.—Foal affected with navel and joint disease. Note the thin, gaunt condition and the swelling of the right knee and left hock joint.

NECROBACILLOSIS

Under this term are included three different types of an infectious disease commonly affecting young pigs, more rarely calves. These affections are known as "sore mouth" or "necrotic stomatitis," "bull nose" or "sniffles," and "necrotic enteritis" respectively. All forms are directly contagious.

Cause.—The Bacillus necrophorus is the cause of all types. This germ gains entrance to the soft tissues of the mouth, nose, and intestines through abrasions of the mucous membrane lining these organs. It thrives in damp litter and soil of pig pens.

Symptoms.—Pigs affected with sore mouth exhibit most of the following symptoms: inability to nurse and eat; fever; ulcers or cankers in the mouth, from the size of a pea to a dime, with red borders and cheesy centers; bad odor from the mouth; blood-tinged saliva; weakness.   In "bull nose" the lining membrane of the nasal cavity becomes red and inflamed, and later necrotic. This causes the animal to breathe with difficulty, hence the name sniffles.   When the germs attack the intestinal wall the symptoms resemble those of hog cholera.

Treatment.—Every pig in the herd should be caught and its mouth and nose examined for sores.   A 2 per cent. solution of potassium permanganate crystals and freshly boiled water should be used to dip the heads of both infected and non-infected pigs.   When cankers are found they are to be scraped and painted with tincture of iodin.   The pens should be cleaned up and disinfected; lime sprinkled about the yards; the udders of nursing sows washed daily with a 1 per cent. solution of a coal-tar dip in water.   After the udder has been washed, it should be thoroughly dried to prevent chapping and garget.

RABIES

Rabies is an acute, infectious, and communicable disease of man and animals affecting particularly the central nervous system.   It is characterized by a variable incubation period of from two to six weeks; in some cases this period may be six months or longer.

Cause.—To date no specific organism has been discovered. However, it has been conclusively proved that a filterable virus is the cause.   The disease is almost always transmitted through the inoculation of the saliva from the bite of a rabid dog.

Symptoms.—In dogs rabies runs an acute and fatal course in practically every case.   The disease in these animals may take either the furious form or the dumb form.

Furious rabies has three stages which may or may not be sharply defined by the actions of the dog.   They are: (1) The melancholy stage which lasts from twelve to forty-eight hours. In this stage the animal likes to hide away, is restless, refuses to eat and either is distrustful or overly affectionate.   (2) The irritative or maniacal stage which lasts from three to four days and is charac-

terized by fury. The patient bites objects, other animals and persons that may cross its path. He has a tendency to stray from home. The voice is hoarse and the animal does not respond to his master's voice. (3) The paralytic stage follows. By this time the dog is thin, haggard, and loathsome in appearance. He is unable to swallow, the jaws become paralyzed and hang down, and the hind quarters become weak. Finally death occurs at the sixth or eighth day.

Dumb rabies differs in that the patient does not exhibit mania. In this form paralysis occurs early and death takes place in two or three days.

The first symptoms in horses and cattle are restlessness and hypersensitiveness. Later the animal becomes furious, and viciously bites and kicks at any object within reach. The course of the disease is five or six days. Paralysis and death are the inevitable end.

Little difficulty should be had in differentiating rabies from other nervous disorders, as in none of them does the animal exhibit the same symptoms of maliciousness. If any doubt exists, small pieces of the brain should be examined by a trained laboratory diagnostician with the aid of the microscope for the presence of Negri bodies. When found these bodies are considered positive evidence of the disease. In the horse they are very small and usually confined to limited areas. Inoculation of rabbits with material from the brain of an infected animal is a reliable means of recognizing the disease.

Treatment.—There is no practical treatment for rabies in farm animals. In man the Pasteur treatment gives good results. It consists in injecting daily for fifteen days an attenuated virus, the virulency of which is increased with each successive injection. Rabies may be effectively controlled and prevented by (1) inforcing a dog tax, (2) by keeping all stray dogs off the streets, and (3) by muzzling all dogs allowed to run at large.

STRANGLES

Strangles, commonly called colt distemper, is a communicable disease peculiar to young animals of the horse family. It is characterized by fever, profuse catarrh of the nasal mucous membrane, and marked swelling of the submaxillary lymph-

glands. It is not a very fatal disease. The mortality varies from 1 to 3 per cent., but may reach 20 per cent. in certain epizoötics. Under ordinary circumstances convalescence occurs in a week or ten days.

Cause.—The cause of strangles is a germ known as the Streptococcus equi. This organism lurks in public sale stables, livery barns, and about places where horses are kept in numbers. In the late winter and spring months these animals are particularly liable to acquire the infection. The period of incubation varies from four to eight days. One attack usually affords life-long immunity.

Symptoms.—In typical cases there will be found a rise of temperature to 104° to 106°F.; general depression; congested mucous membranes; profuse nasal discharge, at first of a watery nature, then thick and yellowish; moist cough; swelling of the lymph-glands under the jaw—which at first are hard, hot, and very tender, later they soften and pus discharges either externally or into the mouth.

Treatment.—A comfortable stall and light, laxative ration must be provided. Of course, the patient should not be kept at work. Cleanse the nostrils with moistened absorbent cotton two or three times a day. For internal medication nothing gives better satisfaction than artificial Carlsbad salts. If the fever is high, quinin may be administered. The treatment of the swollen glands in the throat is purely surgical. To hasten abscess formation a poultice may be applied. As soon as the abscess "points" it should be opened with the finger or a blunt instrument to allow the pus to escape. Syringe out the abscess cavity twice each day with 3 per cent. carbolic acid solution.

TETANUS

Tetanus is a typical acute, infectious disease of the nervous system, characterized by spasmodic contractions of the muscles. Strictly speaking, it is not a communicable disease, although tissue from an infected wound is capable of causing the disease when inoculated into a guinea pig. The mortality varies between 55 and 90 per cent.

Cause.—The disease is caused by the tetanus bacillus, a spore-forming, toxin-producing organism that is naturally found in

certain soils and in mold on horse manure.   Man and the horse possess great susceptibility for virulent cultures.   Sheep and swine are also susceptible.   Infection occurs through wounds of the hoof, or of the skin made by nails, fork tines, splinters, or infected surgical instruments.   In one case a piece of burlap was used to cover the crupper strap which had galled the skin under the tail.   Shortly the burlap gathered a quantity of feces containing tetanus bacilli which were rubbed into the skin and produced tetanus from which the animal died in ten days.   The incubation period is usually from one to two weeks but may be shorter.

Symptoms.—The animal shows violent spasms of groups of body muscles from one to twenty days after inoculation.   When those of mastication are affected the jaws become immovable.   This has given rise to the term "lockjaw."   The ears, tail, and limbs stiffen.   Chief among the diagnostic symptoms in the horse is the protrusion of the membrana nictitans, or "haw," over the eyeball when the head is raised.   A stilty attitude is assumed and a stiff gait when in motion.   Sweating is common in severe cases.   In swine the disease often occurs after ringing and castration and is accompanied by marked trismus.

Treatment.—In mild cases given prompt treatment recovery may be expected.   Thorough disinfection of the seat of infection is the first essential in treatment.   Quiet quarters and provision for comfort are of greater importance than drugs.   Injections of antitetanic serum, produced by injecting horses with increasing doses of tetanus toxin, protect the animal, if given early.   The serum treatment is of slight value after the symptoms of tetanus have become well marked.   A postmortem examination of animals dead from tetanus is usually negative.

TUBERCULOSIS

Tuberculosis is a communicable disease affecting man and animals.   From an economic viewpoint its occurrence in cattle and swine is of most importance.   In 1917 nearly 25 per cent. of all hogs slaughtered in one city were found to be affected with tuberculosis.   Like other communicable diseases, it is both infectious and preventable.   It is characterized by the formation in the internal organs of small nodules or tubercles that have a tendency to become cheese-like and later calcified.

Cause.—The disease is caused by the tubercle bacillus discovered by Robert Koch in 1882. This organism is too small to be seen with the unaided eye and belongs to the acid-fast group. It is difficult to isolate directly from the tissues and grows slowly on artificial culture media.

Infection is usually acquired by eating food or drinking fluids contaminated by discharges from tuberculous animals. Calves and pigs contract the disease by drinking milk from tuberculous cows, particularly raw by-products of creameries, cheese factories,

Fig. 96.—This cow reacted to the tuberculin test five times, but never showed symptoms of tuberculosis. When slaughtered, extensive lesions of the disease were found.

and skimming stations. Hogs having access to the excreta of cattle which have tuberculosis are certain to become infected. When hogs were fed on milk containing the tubercule bacilli for only three days the post-mortem examination held 107 days later showed that 83.3 per cent. of the animals had developed tuberculosis.

Symptoms.—A tuberculous animal often shows no physical signs of the disease (Fig. 96). This is especially true when only one or two organs are involved. Even in cases of generalized tuberculosis there may be no symptoms of the disease. When the lungs are badly affected a cough and some difficulty in breath-

ing may be noted, especially after exercise.   When the intestines are extensively involved a persistent diarrhea is present.   The lymph glands of tubercular organs always show lesions of the disease, as they catch the germs carried away by the lymph. In cattle the lymph glands on the sides of the pharynx are most frequently affected; next in frequency are the bronchial glands
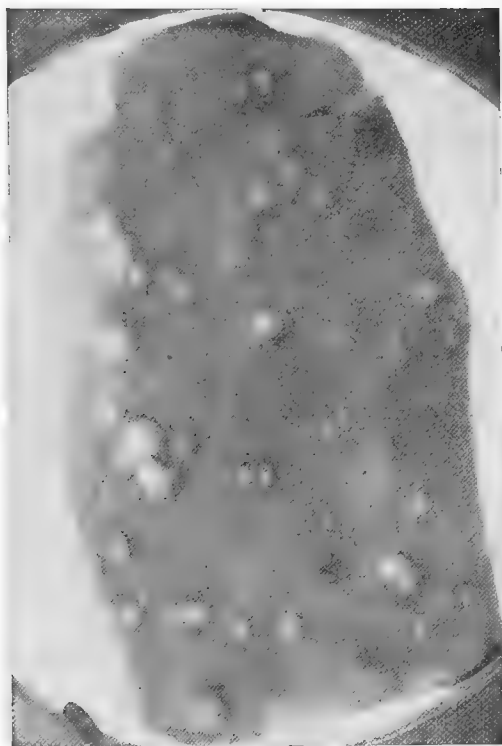
FIG. 97.—Portion of spleen of hog showing many tuberculous nodules scattered over the surface.

at the bifurcation of the bronchi; then the mediastinal glands between the lungs.   When lesions occur on the diaphragm they resemble pearls, hence the name "pearl disease."   In hogs the lymph glands of the neck are affected in about 93 per cent. of all cases of tuberculosis.   The spleen is also commonly involved (Fig. 97).

Diagnosis.—It is difficult to demonstrate the tubercle bacilli in caseous or purulent matter by the microscope, but easy if the material is inoculated into guinea pigs. A biologic test is used to determine the presence of infection in living animals. It consists of injecting tuberculin, a solution of the products of the tubercle bacilli, into the body of the suspect. If the animal is infected, a rise of temperature of more than 2°F. occurs a few hours after the injection. The dose of tuberculin employed for cattle is 2 c.c. per 1000 pounds of weight.

The intradermal tuberculin test is coming into use. It consists in injecting a few drops of concentrated tuberculin between the outer and inner layers of the skin. In case the animal is infected, a small, hard swelling, which is often surrounded by a softer swelling, occurs at the point of inoculation in twenty-four to ninety-six hours. The ophthalmic tuberculin test is also employed; it consists in instilling a few drops of the test fluid into the eye. A reaction is shown by profuse lacrimation and swelling of the lining membrane of the eyelids.

The tuberculin test is recognized as a reliable method of diagnosis. It is not infallible or fool-proof, but is much more satisfactory than a diagnosis based entirely on a physical examination.

Treatment.—The first thing to do in dealing with herds found tuberculous by the tuberculin test is to remove all affected animals from the premises. If in a marketable condition they should be slaughtered at an abattoir where a government inspector is stationed, so that the carcasses may be disposed of in an approved manner. The open-air treatment so commonly employed for man has been attempted for cattle, but the results do not justify the expense. Medicinal treatment is unsatisfactory. The immunization methods that have been tried are impracticable. Preventive treatment consists in guarding the food and drink against contamination with the germs responsible for the disease. Pasteurization of skim milk, whey, and other creamery by-products from skimming stations, creameries, and cheese factories is an effective method of preventing the spread of tuberculosis and other diseases carried by these by-products.

CHAPTER XXII

VETERINARY MEDICINES

THE ADMINISTRATION OF MEDICINES

There are several methods of giving medicine to animals. The methods commonly followed are the following: By way of the mouth, as a drench, or in the feed or drink; by injection under

FIG. 98.—The proper way to drench a sheep.   (Kleinheinz, Sheep Management.)

the skin or into a vein with a hypodermic syringe; by rubbing into the skin, as a blister; by injection into the rectum as an enema.

Quickest results are obtained from medicines administered

375

subcutaneously and intravenously, as absorption is more prompt. However, the method employed will depend on the kind of animal, the form of the medicine, and the nature of the disease. The forms in which medicines are dispensed are liquid, ball, powder, paste and hypodermic tablets.

Liquid medicines are given as a drench by means of a taper-necked bottle, or a dose syringe (Fig. 98). Care should be exercised to avoid strangling the animal through the medicine "going down the wrong way" and passing into the lungs.

Balls or **pills** are placed on the back part of the tongue by the fingers or a balling gun. A gelatin capsule is the most satisfactory covering for this form of medication. Liquid or powdered drugs may be administered in capsules. Compressed tablets are also used.

Powdered drugs are administered in the feed or drink, if they are nearly tasteless, but animals will refuse strong tasting medicines offered in this manner, in which event some other means of administration must be sought.

Electuaries are preparations of medicines in the form of a paste made by mixing with a syrup. The mixture is administered by smearing it on the teeth or tongue.

Hypodermic tablets are employed when the medicine is in condensed form, readily soluble, and free from germs. A small syringe, fitted with a hollow needle, that can be sterilized in boiling water is required to introduce medicines under the skin (Fig. 99).
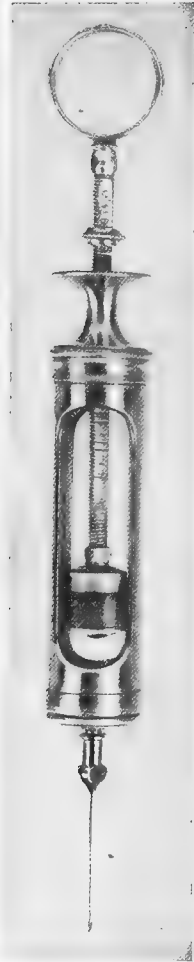
Fig. 99.—Veterinary hypodermic syringe.

THE ACTIONS AND USES OF MEDICINES

Medicinal agents act either locally or generally, depending upon the agent employed and the way it is administered. They are grouped into various

classes depending upon the action they produce when introduced into the body. The most commonly prescribed veterinary medicines belong to one or more of the following classes:

Anesthetics are agents which reduce sensation. They act locally or generally, depending upon the kind of anesthesia desired and the agent employed. Cocain and synthetic preparations of similar chemical composition are used to produce local anesthesia by injecting a solution of the drug into the tissues. Chloroform and ether are general anesthetics. They are administered through the respiratory tracts and act by deadening the central nervous system.

Antipyretics are agents which reduce fever by depressing the circulation, diminishing oxidation, and promoting heat loss by increasing radiation and conduction of heat from the body. They are used to keep the fever within bounds, rather than for dispelling it entirely. Examples are quinin, aconite, acetanilid.

Antiseptics are agents which inhibit the growth of germs, but are not strong enough to kill them or produce irritation to the tissues. They are used for wound applications. Examples are boracic acid, iodoform, tincture of iodin.

Astringents are agents which contract tissues and check secretions. They are used for wounds. Examples are alum, zinc sulphate, tannic acid.

Blisters are agents of an irritating nature applied to the skin for the purpose of bringing more blood to the part and thus increasing the activity of the underlying tissues. They cause little vesicles or blisters containing a straw-colored fluid to form. They are especially useful in chronic inflammatory conditions such as bone and joint diseases. Examples are cantharides, red iodid of mercury.

Cathartics are agents used to evacuate the bowels. They operate by stimulating peristalsis; by increasing the fluidity of the intestines in causing the intestinal glands to pour out secretions; by hindering absorption; by combining two or more of these actions. They are used in a large number of diseases, *e.g.*, constipation, diarrhea, liver diseases, founder, congestion, and dropsy. Cathartics should not be administered to very weak animals, those in advanced pregnancy, or those suffering from peritonitis. A cathartic producing a mild action is known as a laxative; one producing drastic action as a purgative. There are

three groups of cathartics, viz., saline, aromatic, and oleaginous cathartics.

The saline cathartics commonly used are magnesium sulphate or Epsom salts, sodium chlorid or Glauber's salts, and magnesium citrate. These agents have the power to produce an outpouring of fluid from the intestinal walls into the bowels. They act only when taken by way of the mouth. Their mode of action is not certain, but probably is due to the irritating effects of the acid radicle combined with the metallic base. The cells in the bowel walls react by pouring out a watery secretion to dilute the irritant. This results in catharsis. The theory of osmosis does not explain the action of saline cathartics for large doses of sodium chlorid solution do not cause the reaction.

The aromatic cathartics include aloes, cascara, and rhubarb. These act when taken into the body through the mouth or injected hypodermically. They cause irritation to the nerves of the bowels which increases the bowel movements and results in evacuation.

The oleaginous cathartics include raw linseed oil, cottonseed oil, and certain mineral and other oils. Their action is due to the irritating effects of the soap which forms when the oil combines with the bile in the intestines (hydrolysis). A longer time must be allowed for effects from this class of cathartics which are particularly useful in emptying the posterior bowel.

Caustics are agents which destroy tissue. They are used to remove warts and to arrest the formation of proud flesh. Examples are copper sulphate, silver nitrate, butter of antimony.

Disinfectants are agents which destroy germ life. They are used on infected wounds, and on the skin when an operation is to be performed. Examples are cresol, carbolic acid, coal tar dips.

Diuretics increase the excretion of urine by stimulating the kidneys. They are used for diseases in which a more profuse flow of urine is desired. Examples are potassium nitrate, turpentine, sweet spirits of nitre.

Emetics produce vomiting through irritation to the nerves of the stomach. Their greatest value is in connection with small animals that have been poisoned. Mustard and warm water is a homemade emetic. Apomorphin, a derivative of opium, is frequently employed for this purpose. Tartar emetic is used

to stop licking disease of cattle and start cud chewing in these animals.

Enemas are fluid injections into the rectum for the purpose of removing feces and parasites, and of supplying nutrition. Warm soapy water is the best enema for animals.

Parasiticides are agents applied to the surface of the skin for the purpose of destroying infesting parasites. Examples are cresol, carbolic acid, coal tar disinfectants.

Sedatives exert a soothing effect and relieve inflammation by lowering functional activity. They are used as local applications in case of an inflamed udder and similar conditions, and as general depressants in cases of nervousness. Examples are acetate of lead, potassium bromide, chloral hydrate, morphin.

Stimulants increase the activity of the central nervous system, thus invigorating the action of the heart and lungs. They are used in the treatment of various diseased conditions in which there is weakness or paralysis. Examples are alcohol, strychnin, camphor, aromatic spirits of ammonia.

Stomachics increase the appetite, stimulate digestion, check fermentation, and dispel gas from the stomach and bowels. They are used for certain digestive disorders. Examples are hydrochloric acid, bitter herbs, ginger, red pepper.

Tonics improve the appetite and increase vigor by toning up the system. They are especially useful for animals in poor physical condition due to chronic nutritive disturbances. Examples are arsenic, strychnin, iron.

Vermifuges kill and expel intestinal worms. They are used in cases where infestation with worms has been demonstrated by finding the parasites in the feces. Examples are iron sulphate, turpentine, tartar emetic.

THE DOSES OF MEDICINES

The doses of medicines vary with the kind and age of the animal. A good rule to follow is to give small doses at frequent intervals rather than one large dose or larger doses further apart. As a rule, to which there are some exceptions, the relative doses for the various domestic animals are as follows:

Horses..................................	1
Cattle..................................	$1\frac{1}{2}$
Sheep and Goats........................	$\frac{1}{5}$
Swine..................................	$\frac{1}{5}$
Dogs..................................	$\frac{1}{10}$
Cats..................................	$\frac{1}{20}$
Fowls..................................	$\frac{1}{25}$ to $\frac{1}{50}$

The following are a few of the principal exceptions to the rule: the doses of the salts of mercury, lead, and copper are considerably smaller relatively for cattle than for horses; calomel and other cathartics are given to swine in 10 to 40 times the dose for dogs; cats are very susceptible to carbolic acid; fowls are relatively non-susceptible to strychnin; finally, all the domestic animals are especially tolerant to morphin, atropin, and aconitin, as compared with human beings.

Age must also be considered in determining the dose. Here the general rule holds good: give full-grown animals the full dose, half-grown animals $\frac{1}{2}$, younger animals $\frac{1}{4}$, very young ones $\frac{1}{8}$, and sucklings $\frac{1}{16}$ of the dose for the adult.

COMMON VETERINARY MEDICINES

Only the medicines which should be kept on hand for emergency use in doctoring farm livestock will be mentioned. A dustproof medicine cupboard should be provided to keep them in. The names, properties, actions, uses, and doses for the horse of these commonly used veterinary medicines follow. Doses for other animals may be easily computed from the above table.

Aconite is ordinarily dispensed as the tincture of aconite. It is a valuable antipyretic and heart depressant, but is poisonous, so should be given only under the direction of a veterinarian. It is used in the first stages of fever and for inflammatory conditions. The dose is 10 to 20 drops.

Alcohol is a diffusible stimulant and diuretic. Externally it is used as an antiseptic. Internally it stimulates the heart and other organs so is used in the convalescent stage following severe febrile diseases, and in collapse. The dose is 2 to 4 ounces diluted with water.

Aromatic spirits of ammonia is a prepared liquid containing ammonia, alcohol, and water. It is a valuable stimulant es-

pecially for the heart and lungs. Diluted with water in 2-ounce doses it is used in colic and for shock.

Arsenic is a heavy white powder, sparingly soluble in water. Applied to raw surfaces it acts as a caustic. Internally it is used as a tonic especially for horses suffering from chronic digestive disorders. The dose for the horse is 1 to 5 grains in the food If Fowler's solution of arsenic is used the dose is 1 to 2 ounces three times daily mixed with the feed.

Bismuth subnitrate is a heavy white powder almost insoluble in water. It is used in combination with salol for scours of calves. For best results it should be given in 2 to 4 dram doses on an empty stomach and at frequent intervals.

Boracic acid is a fine non-poisonous powder. It is an ideal antiseptic and non-irritating wound dressing. A saturated aqueous solution makes an excellent eye wash. The dry powder is used for dusting on wounds.

Cantharides is the powdered bodies of Spanish flies. It is for external application only and is used as a blistering agent in combination with vaseline or lard.

Carbolic acid may be purchased as crystals and put into solution as required. It is one of our best disinfectants and is employed in a 3 to 5 per cent. solution. Even in small amounts it is a powerful poison. In case of poisoning, a stomach pump is immediately used and then undiluted whiskey is given as a stimulant followed by Epsom or Glauber's salts to form insoluble sulphocarbolate.

Copper sulphate forms as large deep blue crystals. It is fairly soluble in water. Externally it is antiseptic, stimulant, astringent or caustic to raw and mucous surfaces according to the strength applied. Internally it is poisonous unless used in very small doses, but has been employed with some success in combination with iron as a tonic and vermifuge. As a drying application for foot-rot and other diseases of the feet, it gives excellent results. It is less valuable as a disinfectant than is popularly believed.

Creolin is a brown colored fluid containing a relatively large per cent. of carbolic acid. It is an antiseptic, disinfectant and parasiticide, depending upon the strength employed. It is used in 1 to 10 per cent. solutions in water.

Gentian is dispensed either in the powdered form or as a fluid extract. It acts as a stomachic and tonic. It is used in condition powders to stimulate the appetite and aid digestion. The dose is ½ to 1 ounce on the feed or by the mouth.

Iron sulphate or copperas is strongly astringent when applied externally. In combination with charcoal and salt it finds use as a tonic and helps to keep the bowels free of worms. Most tonic powders, prescribed and proprietary, contain iron sulphate. On account of its astringent action, iron sulphate should be mixed with other agents when administered. The dose is 1 dram.

Lead acetate is a white powder, commonly known as sugar of lead, which acts as an astringent. It is used externally in the form of white lotion for its cooling and soothing action as an application to inflamed tissues.

Lime water is made by slaking fresh lime in water and allowing it to stand. The supernatant fluid is poured off and is used for diarrhea in young animals by diluting their milk one-third with it.

Linseed oil is expressed from flaxseed without the use of heat. The raw oil is a valuable purgative and tissue softener. For horses it is given in pint doses. For calves and pigs castor oil is preferable and is given in 1 to 2 ounce doses. Mixed with creolin or a coal tar disinfectant in the proportion of 14:1, linseed oil is a very useful remedy for skin diseases.

Magnesium sulphate is a saline cathartic. It is commonly known as Epsom salts. The salt is very soluble in water. It is best adapted for cattle and sheep. The dose is ½ to 1 pound.

Mercuric bichlorid is an active disinfectant and poison commonly termed corrosive sublimate. It is dispensed in tablets which are dissolved in water to make solutions of desired strength. For the treatment of wounds a 1:1000 solution is used.

Nux vomica is sold in the powdered form; also as fluid extract. Its action is that of a stimulant and tonic. It is used for general weakness, poor nutrition, paralysis, and collapse. The active principle is strychnin. The dose is 2 to 4 drams.

Oil of turpentine acts externally as an irritant and is a frequent constituent of liniments. Internally turpentine is an antiferment and vermifuge. It is used for colic, bloating, and intestinal worms. The dose is from 1 to 2 ounces mixed with raw linseed or other heavy oil.

Pine tar is obtained by the destructive distillation of pine wood. It is a thick, almost black, sticky fluid and contains oil of tar, creosote, carbolic acid, xylol, acetic acid, methyl alcohol, and several other substances. It is used chiefly as an application to the skin and hoofs. Many hoof ointments to stimulate growth of horn contain tar. Oakum soaked in tar is commonly used to pack between the hoof and a pad to cure thrush and canker and keep the horn better nurtured. It is used after dehorning for its antiseptic qualities and to protect against flies.

Potassium iodid occurs as crystals which are exceedingly soluble in both water and alcohol. The chief internal action is that of an alterative. For lump jaw of cattle it appears to be a specific. All glandular swellings are more readily absorbed if potassium iodid is given with other treatment. The dose is 1 to 4 drams.

Potassium nitrate, commonly called saltpeter, occurs as colorless crystals or a crystalline powder and is permanent in the air. It is soluble in 3.8 parts of water. Its action is that of a diuretic and heart sedative. It is used in laminitis, fever, and for many other diseases. The dose is $\frac{1}{2}$ to 1 ounce.

Potassium permanganate occurs as dark purple crystals, permanent in dry air and soluble in 16 parts of water. It is a valuable antiseptic and deodorizer, the action being due to liberation of oxygen, and is employed in from 1 to 4 per cent. solutions. As an antidote for vegetable poisons it has no equal. Potassium permanganate stains the hands so is disagreeable to use. Stains may be removed by washing in a saturated solution of oxalic acid or dilute hydrochloric acid.

Salol is a white powder almost insoluble in water. It acts as an intestinal antiseptic and is used for diarrhea. The dose is 2 to 4 drams.

Sodium bicarbonate is a white odorless powder readily soluble in 12 parts of water. Its action internally is to reduce acidity. It is used in digestive disturbances to correct acidity. For azoturia it is recommended in large doses. One ounce can be given as a dose.

Sodium sulphate occurs as crystals but can be bought dried (anhydrous) with the water of crystallization removed. It is commonly known as Glauber salts. It acts as a cathartic by producing an outpouring of fluid and bringing about a quick

passage of the bowels. This is the best saline cathartic for veterinary use. The dose is $\frac{1}{2}$ to 1 pound dissolved in water and given as a drench.

Tincture of iodin is an alcoholic solution of iodin crystals. Iodin is an antiseptic and disinfectant. It has a penetrating action and is absorbed through the unbroken skin. It is valuable for use in connection with swellings about joints, about wounds, in strains and bruises. As a skin and wound disinfectant it far surpasses any other preparation. For ringworm and similar skin troubles it is highly recommended. Recently a preparation of iodin known as iodin petrox has been recognized officially. It can be used in place of tincture of iodin and has the advantage of being more readily absorbed by the skin, cheaper, and of not staining the hands.

Vaselin is a petroleum derivative. It acts as a soothing agent and tissue softener. It is used as a base for ointments.

The few medicines that have been described comprise but a small number of the 600 or more contained in the U. S. pharmacopœia. They have been mentioned to give an idea of the actions, uses, and doses of those in common use. There is a tendency at present toward using fewer drugs. This has come about with the better understanding of the actions of drugs and the nature of diseases. In time it is likely that not more than 60 of the 600 will be employed at all extensively.

POISONS AND POISONING

DEFINITIONS

A **poison** is any substance that may cause or causes death when applied externally, taken internally, or developed within the body.

Toxicology is the scientific study of the actions, effects, and antidotes of poisons.

Antidotes are medicines employed to counteract poisons. There are three different kinds depending on the way in which they operate: Mechanical antidotes operate by removing the poison from the body; examples are the various emetics and cathartics. Chemical antidotes prevent poisoning by decomposing the poison or by changing it into a compound which is not poisonous; examples are iron for arsenic and starch for iodin. Physiologic antidotes produce an action which will counteract the effect of the poison; an example is coffee as an antidote against morphin.

Poisoning is rare except from accidental causes, and then almost always occurs from the ingestion of poisonous plants. Malicious poisoning is usually attempted with either arsenic or strychnin. When poisoning is suspected all other possible causes should be looked for, as in many cases a careful search will show that something else is actually responsible for the sickness.

The diagnosis of poisoning requires a careful postmortem examination and a chemical analysis of the stomach contents. This is quite expensive as the services of a competent analytical chemist are needed. When a poison is found there is no doubt about the cause of death.

There are three classes of poisons, viz.: (1) animal, *e.g.*, cantharides; (2) vegetable, *e.g.*, loco weed; (3) mineral, *e.g.*, arsenic.

ANIMAL POISONS

Cantharides poisoning results from carelessness in applying Spanish fly blister or carelessness in tying the animal to prevent

getting the blister material in its mouth. Mucilaginous substances are useful antidotes.

Snake venom poisoning is not so common as it was a few decades ago because the poisonous varieties of snakes are nearly extinct in most parts of this country. Apply 5 per cent. carbolic acid solution externally and give strong coffee and aromatic spirits of ammonia internally.

Ptomain poisoning occurs as a result of animals eating food containing protein substances that have undergone putrefaction by certain kinds of bacteria, viz.: B. enteritidis, B. coli, B. botulinus. It is a common form of poisoning in poultry fed on table scraps and hogs fed on garbage. The symptoms are abdominal pain, diarrhea which is often bloody, weakness, and prostration. Treatment is largely symptomatic. Emetics and laxatives are recommended to remove the poisonous ingesta, and stimulants to support the circulation.

VEGETABLE POISONS

Loco-weed poisoning is due to eating freely of three leguminous plants, commonly known as "loco weeds." These plants grow in all our western states, from sea level to the slopes of the highest mountains. The poisonous principle is not known. Animals do not at first readily eat the weed or do so only when food becomes scarce. A taste is soon formed for it, so that addicted animals will leave good food and go without water to search for loco weeds.

The most prominent symptom of locoism is a staggering and uncertain gait, caused by derangement of the nervous system. Horses shy and jump at imaginary objects. The animals gradually lose flesh and sooner or later die of starvation. Death occurs in a comparatively short time in some cases.

There is no specific antidote known for loco-poisoning. Remedies to relieve constipation and Fowler's solution of arsenic in $\frac{1}{2}$-ounce doses twice each day have given the best results experimentally. Most locoed animals with the above treatment will recover, provided the weed is taken from them and they are fed well.

Horse-tail poisoning, caused by eating a plant known as Equisetum, has been reported in a number of states. The symp-

toms are loss in condition, a staggering gait, and increasing weakness. A fatal end rarely occurs if the feed is changed and purgatives are given to rid the system of the poison. A valuable antidote for this and other plant poisons is permanganate of potash; 20 grains dissolved in a pint of water with an equal amount of sulphate of aluminum to increase the acidity of the stomach contents gives best results.

Strychnin poisoning is quite common. This agent is frequently used to kill animals that are no longer useful. It is also used maliciously. Most rat and squirrel poisons contain some strychnin. Sedatives like morphin are employed as antidotes.

Fig. 100.—A typical locoed horse. Note the abnormal growth of tail and mane which is characteristic of the disease. (*Farmers' Bull.*, 1054.)

The general rule applies to this poison that should be followed in all cases where the poisonous agent is taken into the stomach, namely produce vomiting.

Ergot poisoning occurs from the eating of ergot, a fungus found on certain grasses and grains. Most cases are chronic due to the gradual accumulation of the poison in the system. Affected animals may have colicky pains, abort, and the circulation in the tip of the tail, ears, and feet be stopped to such an extent that death of the parts occurs and they drop off. The treatment is to remove the cause and provide laxative nourishing food.

Larkspur poisoning results from cattle eating either the tall or the low larkspur plant. It occurs almost entirely in cattle on the ranges of the west. The symptom that first attracts attention is the sudden falling of the animal. In light cases the animal may be able to get to its feet and walk away after a short time. In severe cases attempts to rise are unsuccessful as the legs are rigidly extended. Death results from paralysis of the muscles of respiration.

The following prescription has given beneficial results when injected with a hypodermic syringe: Physostigmin salicylate 1 grain, pilocarpin hydrochlorid 2 grains, strychnin sulphate $\frac{1}{2}$ grain. By keeping cattle off ranges where larkspur grows in abundance until about the first of July or permitting them to feed for only a few days in succession, it is possible to prevent serious losses.

MINERAL POISONS

Arsenic poisoning occurs from eating paris green, rat poison, sheep dips, and weed killers containing arsenic in quantities. The toxic dose for the horse is 10 to 45 grains; for cattle 16 to 45 grains. Iron oxid is an effective antidote.

Common salt poisoning is not rare in poultry, swine, and sheep that are salt-hungry. It often occurs from animals eating lumps of salt and brine that was used for curing meats. Hogs die in twenty-four to forty-eight hours after consuming too much salt. Three pounds of crushed rock salt killed ten 175-pound hogs the day after it was given. They showed symptoms of intense abdominal pain and died in spasms. Give plenty of water and stimulants as antidotes.

Concentrated lye poisoning occurs in hogs fed on slop with much dish water in it. It has caused the loss of many chickens also. Albuminous substances are helpful to counteract this poison.

Lead poisoning occurs most frequently in cattle for they will eat paint whenever given an opportunity. Poultry become poisoned on lead from eating paint skins. The toxic dose for the horse is 500 grains, for the ox 50 grains. This relative tolerance of the horse to lead is remarkable. The characteristic symptom is a blue line on the gums. Milk and Epsom salts are antidotes.

Mercury poisoning results when animals lick off blue ointment, an agent containing a large percentage of mercuric bichlorid that has been applied to kill lice. Drinking water containing mercuric bichlorid in solution has caused poisoning. In severe cases a bloody diarrhea appears. Milk is a satisfactory antidote. In chronic mercuric poisoning potassium iodid has given good results as an antidote.

APPENDIX

OUTLINE FOR STUDY OF THE CONTROL OF COMMUNICABLE DISEASES

1. Infective agent
2. Source of infection
3. Mode of transmission
4. Incubation period
5. Period of communicability
6. Method of control

    (*A*) The infected animal and its environment:
        1. Recognition of the disease
        2. Isolation
        3. Immunization
        4. Quarantine
        5. Concurrent disinfection
        6. Terminal disinfection
    (*B*) General measures.

As anthrax is a typical communicable disease, it will be taken as an example to show how the above outline may be used in studying each of the diseases described in Chapter XXI.

ANTHRAX

1. *Infective Agent.*—Anthrax bacillus.

2. *Source of Infection.*—Soil, forage, stagnant water, and feces of infected animals.

3. *Mode of Transmission.*—The ingestion or inhalation of the infective agent, and through accidental wounds of the skin.

4. *Incubation Period.*—One to five days.

5. *Period of Communicability.*—While the infected animal is carrying a fever and until lesions have ceased to discharge. Infected objects such as the soil and forage, and the hair and hides of infected animals may be capable of communicating the disease for weeks, months, or years.

391

6. *Methods of control:*
    (*A*) The infected animal and its environment:
        1. Recognition of the disease—Symptoms and postmortem findings confirmed by a bacteriologic examination.
        2. Isolation of the infected animals.
        3. Immunization by means of the simultaneous injection of a hyperimmune serum and a vaccine composed of attenuated cultures of the anthrax bacillus.
        4. Quarantine—A strict quarantine should be enforced during the course of the disease and for ten days after the last case has occurred.
        5. Concurrent disinfection—The secretions and excretions of infected animals and objects soiled therewith.
        6. Terminal disinfection—Stables and contents are to be thoroughly cleansed.
    (*B*) General measures:
        1. Animals presumably sick with anthrax should be placed immediately under the care of a veterinarian.
        2. Isolation of all animals in infected flocks and herds showing a temperature above 104°F.
        3. Immunization each spring of all animals allowed access to contaminated pastures under the direction of the proper live stock sanitary authorities.
        4. Postmortem examinations should be made only by a veterinarian, as the disease is readily acquired by man.
        5. Milk from a dairy in which the disease has appeared should not be used until the temperatures of all the cattle have returned to normal.

DISEASES OF MAN CARRIED BY DOMESTIC ANIMALS

I. By horses:
    Anaphylaxis (through serum)
    Anthrax
    Glanders
    Itch (mange)
    Rabies
    Ringworm

    Sporotrichosis
    Tetanus
II. By cattle:
    Anthrax
    Cowpox
    Foot-and-mouth disease
    Impetigo contagiosa
    Milk sickness
    Paratyphoid fever
    Pus infections
    Rabies
    Ringworm
    Septic sore throat
    Tapeworm
    Tetanus (through vaccine)
    Tuberculosis
III. By sheep:
    Anthrax
    Itch (scabies)
IV. By swine:
    Anthrax
    Foot-and-mouth disease
    Liver flukes
    Tapeworm
    Trichinosis
    Tuberculosis
V. By goats:
    Anthrax
    Malta fever
    Itch (scabies)
VI. By dogs:
    Favus
    Fleas and ticks
    Foot-and-mouth disease
    Infantile splenomegaly (from dogs through fleas)
    Liver flukes
    Mange
    Rabies
    Ringworm
    Tapeworm
    Trypanosomiasis (T. gambiensi)

VII. By cats:
  Favus
  Liver flukes
  Rabies
  Ringworm
  Tapeworm

DISEASES OF SWINE THAT RENDER THE FLESH UNFIT FOR FOOD

1. Anthrax
2. Cysticercosis (measles)
3. Emaciation and anemia
4. Foot-and-mouth disease
5. Hog cholera and swine plague
6. Jaundice or icterus
7. Pyemia
8. Rabies
9. Septicemia
10. Suffocation
11. Tetanus
12. Trichinosis
13. Tuberculosis
14. Uremia and sexual odor

BONES OF SKELETON OF HORSE

Skeleton of the horse	Axial Portion	Head	Skull	Cranium	Occipital 1
					Sphenoid 1
					Ethmoid 1
					Interparietal 1
					Parietal 2
					Frontal 2
					Temporal 2
				Face	Maxilla 2
					Premaxilla 2
					Palatine 2
					Pterygoid 2
					Nasal 2
					Lacrimal 2
					Malar 2
					Superior turbinal 2
					Inferior turbinal 2
					Vomer 1
					Mandible 1
			Hyoid		Hyoid 1
		Trunk	Vertebræ		Cervical 7
					Thoracic 18
					Lumbar 6
					Sacral 5
					Coccygeal 15
			Thorax		Ribs 36
					Sternum 1
	Appendicular Portion	Fore Limb	Shoulder		Scapula 2
			Arm		Humerus 2
			Forearm		Radius 2
					Ulna 2
			Knee		Radial 2
					Intermediate 2
					Ulnar 2
					Accessory 2
					First 2
					Second 2
					Third 2
					Fourth 2
			Cannon and Splints		Large Metacarpal 2
					Small Metacarpal 4
			Pasterns and Foot		Sesamoids 4
					First Phalanx 2
					Second Phalanx 2
					Third Phalanx 2
					Navicular 2
		Hind Limb	Hip		Ilium 2
					Ischium 2
					Pubis 2
			Thigh		Femur 2
			Stifle		Patella 2
			Leg		Tibia 2
					Fibula 2
			Hock		Tibial 2
					Fibular 2
					Central 2
					1st and 2d (fused) 4
					Third 2
					Fourth 2
			Cannon and Splints		Large Metatarsal 2
					Small Metatarsal 4
			Pasterns and Foot		Sesamoids 4
					First Phalanx 2
					Second Phalanx 2
					Third Phalanx 2
					Navicular 2

Total 207

INDEX

397

26