THE FUNDAMENTALS OF HUMAN ANATOMY

THE FUNDAMENTALS OF HUMAN ANATOMY

INCLUDING ITS BORDERLAND DISTRICTS

From the Viewpoint of a Practitioner

BY

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WITH ONE HUNDRED ONE ILLUSTRATIONS

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TO THOSE
WHOSE ESSENTIAL AIM IT IS TO
ADVANCE THE BOUNDS OF OUR
ANATOMIC KNOWLEDGE,

THIS BOOK IS
DEDICATED

PREFACE

The following discussion might, perhaps, be more fittingly entitled "One point of view as to the teaching and learning of anatomy." With this general disclaimer, and the statement that the usual preface data may be found on pages 6 to 7, I offer the following as the theory and aim of this effort. That anatomy is taught to the students of medicine by two groups of men with varying antecedents and aims; those who are essentially anatomists and those who are essentially practitioners. The extremists of these groups naturally have many grave disagreements, but surely no exponent of either extreme seriously questions the value of the other element. Both these groups have as their aim the advancement of the science and the practice of anatomy, even though emphasis is differently placed. These forces should be considered therefore not as opposing but as complementary forces.

However much these groups of teachers may disagree among themselves, every posted observer of either side will agree that the rank and file of practitioners of medicine show an unfortunate lack of knowledge of and interest in anatomy. The importance and practical value of anatomy as an aid to the practitioner in any or all of the subdivisions of medicine deserves emphasis. In so unstable a field as medicine the value of a stock of relatively fixed facts as a foundation for the practitioner can scarcely be overestimated. True, a knowledge of anatomy will not in itself make a diagnostician or a surgeon, but on the other hand a lack of such knowledge is a fatal shortcoming. After making due allowance for the exaggerated importance any group of men necessarily attach to their particular work, the fact remains that any serious attempt to improve the anatomic knowledge of practitioners is worthy of the consideration of all those interested in the advancement of medical education.

Let us counsel together. Admittedly under the present system many or even most medical students get a fairly satisfactory knowledge of anatomy, but the question is—Is the present method of teaching the best that can be evolved, other factors remaining unchanged? It is very natural for us, as teachers, to ignore the shortcomings, or to point out the weaknesses in our present or former students in extenuation, but are we blameless? Anatomy is taught in the medical school because it is of value to the practitioner and the embryo-practitioner is justly interested in anatomic facts in direct proportion to their practical usefulness. These axiomatic principles are all too often lost sight of in the preparation of books and at times perhaps even in the actual teaching of students. Let me emphasize that this is not a discussion of how to advance the science of anatomy, but how to teach students and practitioners of medicine. To the scientist the demonstration of a new fact with its full detail is a matter of the greatest interest. Common experience has abundantly justified this point of view even from the utilitarian standpoint, for what is today an isolated bit of knowledge without practical importance, tomorrow often becomes an element of our foundation. Before a body of medical men the importance of the study of anatomy as a pure science certainly should require no defense, for practitioners must recognize that most of our advances in anatomy—and in later years there have been many—are necessarily based on abstract scientific effort. But to maintain such a point of view in the teaching of students or practitioners of medicine, as is sometimes unconsciously done, is in the opinion of most practitioners a serious pedagogical error.

A stock tendency of the reactionaries is the attempt to restrict the teaching to pure or straight anatomy, meaning thereby such anatomy as can be seen by the unaided eye. But the progressives maintain that anatomy never has been taught strictly from this point of view, and that if it should be so taught it would necessarily yield an artificially narrow conception of the subject. They point out that the action of muscles, which is technically function or physiology, that the question of rupture, which is technically disease or pathology, that the subject of development, which is technically embryology, and so forth indefinitely, have long been treated as intrinsic parts of anatomy. The progressives maintain that the great modern advance in our conceptions of anatomy is due to an attack on the subject from all available points of view; they point out that the sidelights from microscopic anatomy, zoology, embryology, physiology, pathology, and the practice of medicine and surgery, are vitalizing anatomy by breaking down what are in reality artificial barriers. In practice many of these important borderland discussions, belonging distinctly neither to one chair of the medical school nor the other, are omitted from the students' course. Perhaps the most striking example of this is the serious omission of references to practical anatomy from books on general medicine. To cite a concrete illustration at random, the otherwise very detailed articles on cerebrospinal meningitis and tetanus in Osler's *Modern Medicine*, make no mention of the normal relative strengths of the muscle groups in connection with the contractures so characteristic of these diseases. The practical importance of these borderland interrelationships of anatomy must be conceded by all, hence the argument resolves itself into the question of who shall teach this field. The practitioner, whose knowledge of anatomy is necessarily limited, or the anatomist, whose knowledge of practice is limited, or both?

Most of the newer anatomies and the newer editions of the standard works recognize the force of this reasoning and by bringing in borderland discussions make a radical departure from former standards. But as these sidelights have been progressively added to the already large books on anatomy, and nothing subtracted, these enlarged volumes have gradually grown into encyclopedias of our entire anatomical knowledge of the human body. They unquestionably fill a most useful place, for the advanced student as a reference work and for the beginner on account of their summaries and wonderful illustrations. But as textbooks, their very completeness and scientific detail makes them almost impossible. No intelligent individual ever literally read one of these books through, except perhaps the author, and he usually divides the burden by means of sectional authorship. Every posted observer recognizes that the amount of detail a student can absorb without losing his bearings varies markedly with the individual, and that the attempt on the part of the ambitious students to master too much detail only too often results in confusion. The time-honored rule of teaching the fundamentals of a subject before attempting to fill in the detail demands recognition, if we are to avoid "mental indigestion" of our average and even of our best students. The dissector group of books on account of their lesser size furnish a text, much more readable and understandable for the student. The shortcomings of those in widespread use, according to the practitioner's point of view, lie in too great an insistence on detail and too little recognition of the borderland interrelationship of anatomy. To give a concrete illustration of a tone, which in my opinion runs throughout these books, the dissector in most widespread use devotes approximately one-fifteenth of its consideration of the upper and lower extremities to the cutaneous nerves, a topic of almost negligible practical value. The compend class of books are too often simply abridged catalogues of anatomic facts without explanation.

After frankly stating my views, I set to work to write what I consider a modern textbook of human anatomy. This book will be written on a progressive system; that is, the essential facts will first be emphasized and then later on details and sidelights will be gradually added. Every term will be explained at its first appearance so that any student without previous special education should be able to follow the text, always provided the preceding parts have been understood and retained. As the title suggests, the rather old-fashioned pedagogical rule of "teaching more by not attempting to teach too much" will receive recognition. For the sake of brevity and clearness a dogmatic style will be adopted, leaving detailed argument and varying opinion for more complete works. A conscious attempt has been made to pay more regard than has been customary to the modern pedagogical emphasis on the correlation of ideas. Logic will be introduced so far as possible to take the place of memorizing, of which there is at best in anatomy necessarily a great amount. The advantage of this method is that in practice a fact held by understanding is retained much longer and more effectively than one entrusted to memory. The text will follow the Basle revision of anatomical nomenclature, such minor variations as are used having been discussed elsewhere.* As this book makes no pretense except as an auxiliary to more complete works, only such diagrammatic illustrations will be used as seem absolutely indispensable.

To the student I should like to emphasize the fact that very many anatomic points can be made out on his or her own body, which has the obvious advantage of being ever present. The drawings and plates of the modern larger anatomic works are of unquestionable help while an articulated skeleton is more than worth its trouble and expense. But of course no aid approaches in value that of

* Some Suggested Changes in Nomenclature—Anatomical Record, xiii, No. 3, pp. 165–168.

actual dissection, for the guidance of which I trust sufficient directions are to be found in the text. A fair general conception of the whole area under consideration should be acquired before any attempt is made at dissection. This rule will minimize mistakes and reduce the necessity for minute details of dissection rules and for expert supervision.

My confidence in the aims of this book is greater than my faith in the performance! It is not written for the extremists, whose criticisms respectively will surely be that it is altogether too detailed and altogether too lacking in detail. But the anatomic point of view is of so great practical value in the general practice of medicine and surgery that the embryo-practitioner or practitioner must surely be repaid for whatever time is devoted to the subject. If this volume tends in any degree, directly or indirectly, to bring the teacher and student of anatomy into closer sympathy, it will have fulfilled its mission.

Let me here acknowledge thanks to Doctors Tupper, Neilson, Sluder, and Dock, of St. Louis, for their helpful criticisms and encouragement; to Mr. Wm. H. French for the excellent way in which he has fulfilled my simple wants in regard to illustrations; and above all, to the publisher, C. V. Mosby Company, for optimistic faith in the practical value of my conception.

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CHAPTER I

INTRODUCTION

Subdivisions of Anatomy

Anatomy, derived from old roots meaning dissection, refers nowadays to our so-obtained knowledge of structure. The term anatomy is commonly used in the consideration of the structure of plants or animals, though figuratively it has been applied to almost any knowledge of structure. Dissections such as can be seen by the unaided eye are known as macroscopic or **Gross Anatomy,** in contradistinction to microscopic anatomy or **Histology** (macro = large; micro = small). Purely as a matter of teaching convenience the gross and the microscopic anatomy are ordinarily considered in separate texts and courses, though it is obvious they are mutually strongly dependent.

Historically gross dissection was practically the only fruitful method by which knowledge of the human body's structure was obtained. The gradual improvements in the microscope and its application to the study of anatomy resulted in the discovery of **cells in plants by Schleiden, in 1837; of cells in animals by Schwann,** in 1838. This was a revolutionary step forward in our understanding of anatomy. Cells gradually became recognized as the essential element of all life. **Embryology,** the study of development, became intelligible under the new discoveries and began to shed great light on many of the previously darkest spots of our knowledge. **Comparative Anatomy,** the study of the corresponding parts in various animals, has added materially to our understanding of human anatomy.

Aside from these direct methods the science of anatomy has received valuable contributions from the sidelights of other studies. Thus, as anatomy has aided in our conception of physiology, the study of function, so physiology has in turn keyed up our appreciation of practical points in anatomy. The same statement applies with equal force to pathology, the study of disease. The science of medicine in all its branches owes a great debt to anatomy, which nowadays is beginning to be repaid. A modern emphasis on the close interrelation of all divisions of our medical knowledge is making headway against the historically established system, the so-called pure anatomy as learned simply from gross dissection. The modern anatomic text tends more and more to consider structure from all the available sidelights and points of view.

Cells

The essential building stones of all life are the cells. Cells, varying in size in the various animals and plants and parts thereof, are all microscopic in size and therefore were unknown before the perfection of the compound microscope. An average cell when magnified one hundred times, appearing to the eye the size of an ordinary pinhead, yields a rough working conception of their size. Cells are made up of a more or less centrally placed core or **nucleus** and a white-of-an-egg-like surrounding zone known as the **cytoplasm.** With the amount of light of the microscope cut down, the nucleus appears as a granular dark mass, and when stained, commonly takes on a much deeper color than the cytoplasm. The cytoplasm under ordinary circumstances appears homogeneous, but often with special stains various types of granules and finer markings can be made out.

Very simple animals and plants are made up of a single cell, characteristically having a nucleus surrounded by cytoplasm. Some of the very smallest of organisms do not have a definite nucleus, such for example are the bacteria groups. It has long been a heated subject of debate as to whether bacteria belonged to the animal or vegetable division of living things, and the argument is still open. The larger one-celled organisms with a distinct nucleus are readily classified either as animals or as plants. Ascending the scale from the lowest animals and plants are the higher animals and plants, made up of a number of cells, and with this anatomic change comes the beginnings of the division of labor. All the cells contribute their share towards the life of the individual plant or animal,

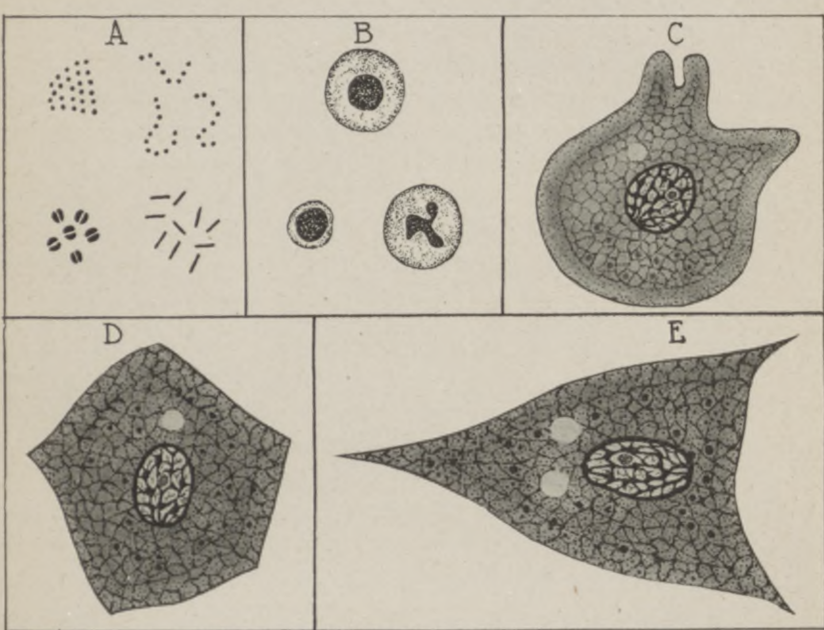

Fig. 1.—Illustrating variations in the size of characteristic body **Cells** as contrasted with the bacteria and the one-cell animals.

A. Bacteria of various types and sizes.
B. Human white blood cells of various types and sizes.
C. Ameba, as example of one-celled animal.
D. Human surface-covering cell.
E. Human young connective tissue cell.

SCALE:

A large white blood cell = 10 micromillimeters = .01 millimeter.
⅜ inch plus as in diagram = 1 centimeter = 10 millimeters.

$$\frac{10.00}{.01} = 1000 \text{ magnification.}$$

but groups of cells are set aside, specialized in structure and function. One of the early groups of specialized cells are those set aside for the function of reproduction.

In the one-celled plants and animals, there is a simple type of reproduction by which the parent cell divides into two; each of these in turn may divide into two, and provided conditions are favorable, this process, so far as we have been able to check it up, may continue *ad infinitum.* In the more highly specialized animals and plants, when once a group of cells is set aside for reproduction, then these cells, and these only, retain the power of producing a new individual. But most of the other body cells retain the power of reproducing themselves until the death of the individual. But even further, it has been demonstrated that cancerous breast cells, after the death of the mouse of which they were originally part, can be transplanted artificially from one mouse to another, reproducing themselves *ad infinitum.*

Mitosis, or Karyokinesis

The division of an animal or plant cell into two is ordinarily a mathematically exact process known as mitosis (thread-splitting). The nuclear granular material becomes arranged as a thick coiled thread, which then breaks up into a number of equal-sized sections or segments. The number of segments varies in different plants and animals, but is a fixed number for any particular kind of plant or animal. Each of these segments then splits longitudinally and is drawn off to its side of the nucleus. Thereupon the remainder of the cytoplasm divides equally, and two new cells are the result. Wherever in animal or plant life cells are reproducing themselves rapidly, provided special precautions are taken for the rapid killing and special staining, these figures can be seen abundantly. The division of cells without these careful procedures occurs in animals and plants, but it is questionable whether it is ever truly a normal process. It is known as amitosis (a = without).

Reproduction

A special group of sexual cells take care of the production of new individuals in the more complex plants and animals. Reproduction depends upon the union of the male cell, the **spermatozoon,** and the female cell, the **ovum.** The ovum contains sufficient nourishment to care for the embryo after fertilization until other sources of nutriment are established. Spermatozoa are ordinarily actively motile and normally a single one makes its way into the ovum. The two nuclei mingle and then the characteristic mitotic division follows.

The resulting two cells divide into four, the four into eight, and so on until the individual plant or animal is fully developed. When the animal has reached its adult size, the cells stop further growth and only reproduce what is lost through wear and tear. The control of this occurrence is still one of the unsolved mysteries of life. During early development the irregular mass of cells is spoken of as the **morula** (mulberry-like). As development proceeds the morula becomes hollowed out and becomes known as the **gastrula** (stomach-like). Then the three important primary layers of the embryo develop: the outer layer or **ectoderm,** the middle layer or **mesoderm,** and the inner layer or **endoderm.** These layers maintain their relative positions and are guides in the study of the development of the higher animals.

Segmentation

The principle of segmentation runs through the animal kingdom. In the more complicated animals it is Nature's provision to make the different sections or segments firm and to allow freer motion between the divisions. This underlying phenomenon has necessarily a great influence on the structure of all the higher animals in the scale, including man.

Bilateral Symmetry

The principle of bilateral symmetry, the two sides alike, is based on the problem of locomotion and is the rule among the animals. Exceptionally, on account of method and mode of life, some animals, such as the flounder fish, or the attached animals, fail to show this common attribute. Naturally this bilateral symmetry has a great influence on the anatomy of most animals, including man.

The Vertebrates

Animals are classified into two great divisions according to the presence or the absence of a backbone, the **vertebrates** and the non-vertebrates or **invertebrates.** The vertebrates have a bony supporting framework inside their bodies and are the higher animals in the scale. The vertebrates are divided into five classes, as follows: (1) **Pisces,** or fish, such vertebrates as breath in water; (2) **Amphibia,** as frogs, such vertebrates as breathe during one part of their life in water and during the other part on land; (3) **Reptilia,** as snakes, such vertebrates as have a scaly skin, lay eggs, and breathe in air throughout life; (4) **Aves,** or birds, such vertebrates as have feathers, are warm-blooded, and brood their eggs; (5) **Mammalia,** such vertebrates as have a mammary gland. The mammalia give birth to their young living and well developed, and suckle them at the breast. Man, as a matter of common knowledge, belongs to the mammalia.

Descriptive Terms

Universal usage has fixed the standard of naming anatomic relationship of man according to the upright position, with the arms at the sides and the thumbs turned outward. This arbitrary anatomic rule should be universally adhered to, no matter what secondary position the body or parts thereof may happen to assume. Thus we speak of the front or **anterior** surface of the body, and the back or **posterior** surface. In relation to the midline of the trunk anatomists in the past have made use of the terms, outer, or **external,** and inner, or **internal.** Further, we speak of a part as being above, or **superior** to, another when it is nearer the top of the head, in contradistinction to below, or **inferior,** when it is nearer the soles of the feet. This resume gives the three dimensions of space in both English and Latin, so it would appear that all possible requirements of anatomy must be satisfied.

But most animals go with their bellies paralleling the ground and are named anatomically according to this position. This different relation to space causes great confusion in comparing the anatomy of the lower animals with man, and in order to remedy this condition, other terms have been more or less successfully introduced into human anatomy. Thus the terms belly, or **ventral** surface, and back, or **dorsal** surface, have gained considerable usage in place of anterior and posterior. On the other hand, the terms **cranial,** or towards the head, and **caudal,** or towards the tail, have made but little progress in human anatomy against superior and inferior. The relative values of external and internal do not change, whether the animal be in the upright or in the belly parallel to the ground position; hence in this case it was not found necessary to introduce new terms. The descriptive terms ventral, dorsal, cranial, and caudal have the advantage of being unchanged, no matter what be the relation of the animal to space, and hence have great value in comparative anatomy.

The adjective **superficial,** or toward the surface, is of great descriptive value in contradistinction to **deep**. As a matter of fact, the term external has been very commonly used in the sense of superficial, and internal in the sense of deep. This double usage of the terms external and internal is obviously a very possible source of confusion. In order to obviate this danger, modern anatomists have advocated and practiced substituting the terms **lateral** for "to the outer side," and **medial** for "to the inner side," and now use the terms external and internal only in their secondary sense. As this book follows the usage of the B. N. A.,* the terms lateral and medial will be adopted instead of external and internal.

Systemic versus Regional Anatomy

Experience has evolved two main lines of attack in the pursuit of the study of anatomy. Either a single tissue, a collection of cells of similar structure and function, such as the skin, or muscles, or bones for example, may be considered as a unit and traced through the body. This is known as the systemic plan. Or a part of the body may be studied in detail, considering all the tissues taking part, which is known as the regional, relational, or topographic plan. Each method has its obvious advantages and its equally obvious disadvantages. From neither system alone would it be possible to gain a practical knowledge of anatomy. Therefore this book will first take up an outline of the main points in systemic anatomy, leaving the modifications and greater detail for the regional division.

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* The last revision of anatomical names, completed in 1895, was the end result of a discussion by a congress at Basle, Switzerland. The revised list of anatomical names has become known as the Basle Nomina Anatomica or, abbreviated, the B. N. A.

PART I

SYSTEMIC ANATOMY

CHAPTER II

THE SKIN AND MUCOUS MEMBRANES

THE SKIN (CUTIS)

The word *skin* means the protective surface covering of the exterior of the human body primarily, although it is also used to name the corresponding layer in some of the lower animals. A protective external layer is found variously developed and modified throughout the animal kingdom. Some lower animals have a relatively soft covering, such as worms or caterpillars, while very tough coverings are represented by the shell-fish and lobster groups. A very common expedient of many incased animals, to allow for an increase in size, is to throw off their outer covering in one piece, for a while being soft-shelled, but shortly reforming a new and larger covering. This phenomenon is popularly known, for instance, in regard to insects, crawfish, and snakes.

Epidermis

Human skin is made up of two structurally and developmentally distinct layers, the **dermis** and the **epidermis** (epi = upon). These layers are normally firmly fixed to each other, there being elevations and depressions on the outer surface of the dermis fitting into corresponding depressions and elevations of the inner surface of the epidermis. A water blister following a superficial burn or injury is a commonly known phenomenon, and is a collection of fluid between these two layers. On account of the relatively poor preservation of dissecting room bodies, the epidermis over great parts of the body can commonly be peeled off from the dermis in large sheets. On microscopic section the epidermis may be noted to be made up of a **stratified squamous epithelium** (layered flat surface-covering). The deeper cells are roundish and are continually undergoing reproduction via the mitotic process. As the older cells are shoved up from the deeper layer they gradually lose their finer anatomic markings, flatten out, die, and eventually are cast off from the surface. The epidermis is derived from the ectoderm, the outer layer of the embryo.

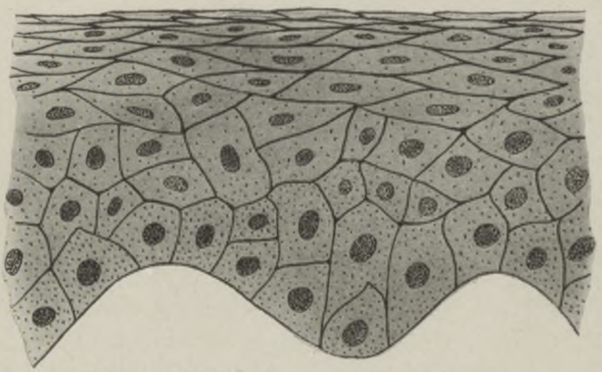

Fig. 2.—Stratified squamous epithelium (x 300).

Dermis, or Corium

The dermis on microscopic examination is found to be made up essentially of **white fibrous connective tissue.** Young white connective-tissue cells are roundish and possess the usual power of mitotic division. As development proceeds they lengthen out and eventually form strong, long fibers, which when grouped with similar strands appear to the unaided eye as a white bundle. These fibers are not living structures, but are simply the product of living cells, not being any more alive than the lime salts of the bones of the body or the shell of an oyster. But living connective-tissue cells are found amidst these strands, lying dormant unless called into activity by injury, when they assume the task of producing new fibers. Rather similar fibers, known on account of color and consistency as **yellow elastic fibers,** are admixed in a variable proportion. These primary bundles are interlaced and woven in all directions, which equalizes the strength against any stress and strain. The strength of the dermis layer among animals is popularly recognized in its commercial form of leather, the B. N. A. term **corium,** meaning

Fig. 3.—Young connective tissue cells (x 600).

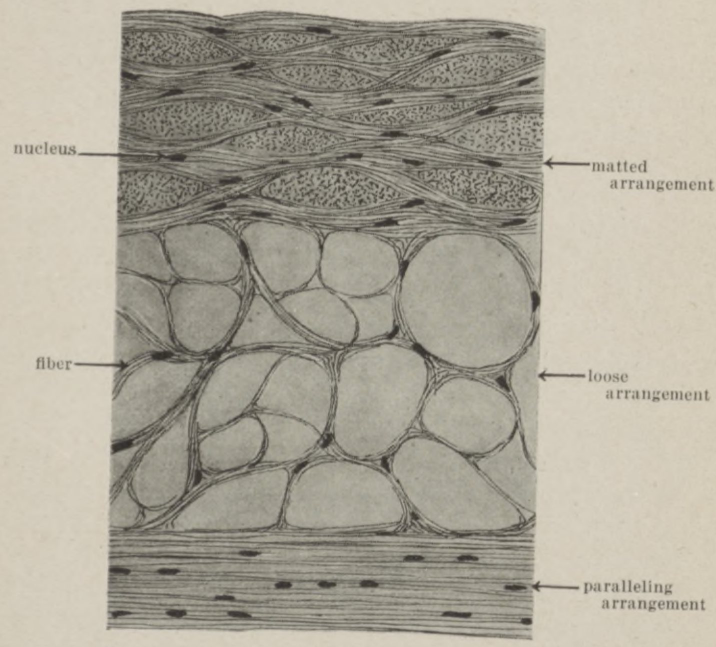

Fig. 4—Fully developed connective tissue (x 250).

leather. The dermis is derived from the mesoderm, the middle layer of the embryo.

Variations in Thickness

The skin forms a complete covering for the exterior of the body. It is a matter of common knowledge that it varies in thickness and strength according to age, vigor, and localization. The lateral surfaces of the thigh and arm, for example, have much thicker skin than the medial surfaces. The scalp, palm of the hand and sole of the foot have extraordinarily thick skin, whereas the eyelids have an extremely delicate covering. The dermis and epidermis take ordinarily an approximately proportional part in these changes in thickness. The epidermis varies from a tissue-paper thinness over the eyelids of a young child to a layer perhaps an eighth of an inch thick over the palm of a manual laborer. Except for the deeper layers, there is obviously no need for vessels or nerves in the epidermis and none exist. The dermis averages about ten times the thickness of the epidermis, though in regions especially exposed to much pressure, as for example the palm of the hand and the sole of the foot, the epidermis may be even thicker than the dermis. It is obvious that the dermis on account of its strength would resist for a considerable time the escape of pus, hence the knife is often justly used to hasten the process.

Pigment

All normal human beings have a certain amount of pigment in the deeper layers of the epidermis, which serves to prevent the penetration of the sun's rays. This pigment serves to protect the living cells against the injurious effect of bright sunlight, the amount of pigment increasing on exposure to the sun's rays. The term "albinos" is used to designate those human and lower animals which absolutely lack this normal pigment (albus = white). The dermis is a dense white even in the colored races, so the popular saying that a negro's color is only skin-deep is not scientifically true, the pigmentation being only epidermis-deep.

Accessories

The **hair** (pili) and the **nails** (ungues) are special structures formed through the activity of the epidermal cells. In health the hair and nails are continually added to at the root and broken or cut off at the end. Hair, as a matter of common knowledge, varies according to age and sex, and according to the different parts of the body. The scalp, eyebrows, and in the male, the beard area are examples of luxuriant growth, while the palms and soles have none. Further where parts of the body would tend to chafe by friction, as in the armpits, for example, a heavy growth of hair tends to keep the surfaces apart and thus prevents irritation. Two small sacs lined by a single layer of modified epidermal cells pour their oily secretion into the root cavity of each hair. These sacs with their collecting ducts are known as **sebaceous glands.** Another general system of glands, also derived from the epidermis, are the **sweat,** or sudiferous, **glands.** These sweat glands are scattered over the whole surface of the body and are the mechanism for the evaporation of water with loss of heat from the body surfaces. The nails and the sebaceous glands lie outside of the deep layers of the dermis, while the hair roots and the sweat glands go through the dermis into the underlying tissues.

MUCOUS MEMBRANES

Mucosa

Wherever the skin turns in at the various external openings of the body, it becomes modified into a mucous membrane. Some of these openings are the nose, mouth, anus, penis, and in the female, the vagina. The characteristic feature which gives these surfaces their name is the secretion by special cells of a thick, viscid, transparent semifluid known as mucus. At these openings of the body the surface covering is developmentally and structurally a continuation of the epidermis, and is made up like it of stratified squamous epithelium. As the interior of the body is not so exposed to injury, the dermis connective tissue layer is not represented. The absence of a dermis layer explains why the small blood vessels can be seen through a mucous membrane, yielding the characteristic pink color. Under the epithelial covering lies a loosely woven connective-tissue layer, containing fat in its meshes and very small vessels and nerves. The mucous glands lie in this layer and pour their secretions via a small duct on to the surface. This fatty tissue layer together with its epithelial covering is known as the mucosa. On the deep surface of the mucosa lies a firm layer of matted white fibrous tissue known as the submucosa (sub = under).

Submucosa (Tela Submucosa)

The submucosa, the layer lying under the mucosa, is made up essentially of strong white fibrous tissue woven in many directions. It is this layer that gives the strength to the parts and which must

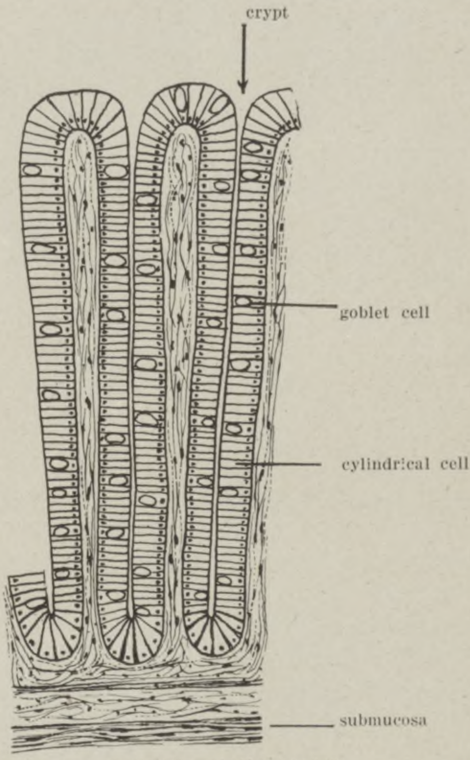

Fig. 5.—Simple cylindrical epithelium (x 100).

be carefully sewed up in various surgical procedures. So-called catgut is made from this fibrous layer of the intestinal tract of sheep. It is further this layer which is utilized as a container for the chopped meat in the various types of sausages. The larger vessels and nerves of the part lie deep to the submucosa and send branches through into the mucosa. Under the submucosa lie the muscles, which will be considered under a special heading.

Types of Epithelium

But this stratified squamous epithelium, occurring near the body-openings and for a varying distance inward, is not the only or even the commonest type of covering for the mucosa. The stomach, intestines, and womb, for example, are lined by **simple columnar epithelium,** i. e., a single layer of column-shaped cells as a surface covering. The stratified squamous epithelium is used essentially as a protective covering, whereas the simple columnar lines such surfaces as have to do with secretion or absorption. The simple columnar cells are not commonly arranged in a straight surface line, but usually dip down into deep pockets known as **crypts** (crypt = hidden). Roughly speaking, about every tenth cell is modified in structure to what is known on account of its shape as a **goblet cell,** which specializes in the secretions of mucus, taking the place of special mucous glands. As individual cells die or are destroyed, the neighboring cell divides and takes its place. The presence of crypts obviously greatly increases the epithelial surface without adding to the bulk.

The smaller collecting ducts of the various glands of the body are lined by simple columnar epithelium without crypts. Presumably due to the extra wear and tear, the larger collecting ducts of the compound glands are lined by a **stratified columnar epithelium.** As this stratified epithelial type contains no goblet cells, mucous glands in the underlying tissues pour their secretion via small ducts on to the surface. This stratified columnar epithelium differs from the stratified squamous epithelium in the fact that the uppermost cells are still living and are columnar in shape. The other minor modifications of the epithelial types will be taken up in the regional considerations.

Such parts of the digestive, respiratory and genital tracts as are lined by a columnar epithelium are generally speaking developed from the endoderm, the lining of the primitive body cavity of the embryo.

CHAPTER III

SUBCUTANEOUS FATTY LAYER AND DEEP FASCIA

SUBCUTANEOUS FATTY LAYER (PANNICULUS ADIPOSUS)

The subcutaneous fatty layer is the loose fatty layer, which throughout the body lies just under the skin (sub = under; cutaneous = skin). A loose connective-tissue layer holding fat-containing cells richly in its meshes is also known under the term of areolar tissue. Instead of subcutaneous fatty or areolar layer, the term superficial fascia has become fairly established, but this unfortunate term should be corrected, inasmuch as fascia plays anatomically and functionally a minor part.

Variations in Thickness

This subcutaneous fatty layer, or superficial fascia, is obviously continuous under the skin covering of the entire body. It is a matter of common knowledge that the amount of fat in its meshes varies greatly in different individuals and in different parts of the same individual. It is relatively thick over the buttocks and belly wall, and thicker over the lateral surfaces of the thigh and arm than over the medial surfaces. It is so thin over the eyelids even in excessively stout individuals as to be almost nonexistent. It varies also in consistency in different parts of the body, due to a proportional change in its constituent tissues. For example, over the palm and soles and over the scalp the amount of the fibrous tissue element is greatly increased.

Fat Cells

Fat cells specialize in the power of gathering a ball of fat within themselves. Young fat cells are noncharacteristic, roundish cells, which possess the power of mitotic division, replacing those lost by wear and tear and also under certain circumstances increasing in number. The adult form of functionating fat cell is characterized by gathering a large ball of fat within its outer cell wall, which forces the nucleus to the side and makes it assume a crescent shape. The stored-up fat serves as a reserve food supply, but has other recognized functions. These cells loaded with fat are held in the meshes of a delicate connective-tissue framework, which can be seen by the unaided eye, or readily under the microscope whenever, as in the usual preparations, the fat is dissolved out.

Heat Radiation

This subcutaneous fatty layer contains a great number of small arteries, veins and nerves. The larger nerves are the cutaneous branches, which serve to supply sensation to the skin. The arteries with their corresponding veins serve to nourish and care for the skin and the subcutaneous fatty layer, but also subserve an entirely different function. The vessels are in reality larger and more numerous than would be required were it not for the necessities of heat radiation. The activities of the body constantly develop heat, and the excess is thrown off by a nervous heat regulating center, which causes more blood to flow in the surface vessels. By throwing the overheated blood into small vessels near the surface and with the aid of sweat gland evaporation, the body in health keeps the temperature in normal range, and in disease keeps it from mounting too high. The flushed appearance of the skin after violent exercise or during high fever represent Nature's effort to get rid of extra heat. During high fever, except during a chill when heat is being rapidly produced and not radiated, it is a serious condition if the skin and subcutaneous layers are not engorged with blood, for that condition represents a loss of control by the heat-regulating center.

The amount of fat in the subcutaneous fatty layer varies directly with the total fat of the body. As a matter of common knowledge the heat regulation of the body is markedly affected by the thickness or thinness of this fatty layer. Very stout people to all practical intents and purposes have an inside overcoat under their skin, and at all times have difficulty in getting rid of excess heat. Very thin people and especially very old people, who have lost their fat, properly take extra precautions to prevent undue loss of body heat.

Superficial Venous System

Another structure found throughout the subcutaneous fatty layer is the superficial venous system. This system of veins has absolutely nothing whatever to do with the nourishment of the layer nor with the system of heat radiation. Veins are vessels which return the blood to the heart. These veins are, as it were, accidentally located in this anatomic layer and will therefore be considered under the general topic of vessels.

An occasional structure is the cutaneous muscle, but this discussion will be postponed until reached in the regional considerations.

FASCIA

The fascia is a matted layer of white fibrous connective tissue, which encases the muscles and special organs (fascia = wrapper). A main function of this layer is to form a firm compartment for the various muscles and muscle groups. It is in the proper sense of the words a fascia made up of white connective-tissue fibers, its constituent fiber bundles being woven in at least two directions and being without any other tissue admixture. As described in connection with the dermis, a few white connective cells are to be found lying semidormant among the white fibers. The dermis differs from the fascia in the character of its weaving and in the presence of yellow elastic fibers. The descriptive "deep" has been added to distinguish the fascia layer covering the muscles from the improperly named superficial fascia, which is in reality the subcutaneous fatty layer.

Intergroupal Septa

The fascia not only surrounds all muscles on all surfaces, but is continued as a double thickness mat bridging the spaces between neighboring muscles. If the skin and subcutaneous fatty layer were absolutely removed from a dissecting room body, the whole body would be found covered by a layer of deep fascia, varying, however, greatly in strength in the various parts. Not only is the external surface covered, but partitions are sent in between the various muscles and muscle groups down to the bones. These partitions between muscle groups are known as intermuscular septa, but more accurately phrased, they are intergroupal septa. These strong fascias attached to the bones very commonly serve as surfaces from which muscle fibers arise.

Variations

The thickness and strength of this fascia layer varies according to age, physical vigor and part of the body. The strongest deep fascia is found on the lateral surface of the thigh, and modified in the palms of the hands and soles of the feet, while the weakest deep fascia is found over the eyelids and the back of the hands and feet. A direct proportion exists in general between the power of a muscle group and the strength of the fascia. Usually the fascia is not so well developed over the fleshy part of the muscles as it is over the sinew or tendon running off from the muscle, the fascia forming a sheath around the tendon and holding it in its proper position during contraction of the muscle. At the wrist and ankle, for example, the fascia layer is specially modified and strengthened in order to hold these tendons down to the bone when the parts are moved.

But fascia has other similar important functions. It surrounds all the organs of the body and together with other factors to be considered in the special sections holds them normally in their proper position. It further forms sheaths or compartments around the vessels and nerves and thereby tends to hold them in their place.

Practical

The anatomy of these fascial layers has great practical interest, both from the diagnostic and the treatment point of view, whenever pus collects down deep in the tissues. On account of the physical toughness of the fascia one would expect pus to have great difficulty in working through, at any rate over all parts where the fascia is thick. If pus is not given an artificial point of least resistance by an incision, it travels along the natural lines of least resistance, at times causing a serious spreading of the infection. To be sure certain cold abscesses should not be opened, but this discussion would carry us too far afield. Suffice it to state that the anatomy of the fascia is a problem of real practical importance.

CHAPTER IV

MUSCLES (MUSCULI)

Muscular tissue is made up of specialized cells or groups of cells, which possess the power of contracting in one direction only. This action is normally brought about through a nervous impulse, but it may be caused by many other types of stimulants. Muscle is developed from the mesoderm, the middle layer of the embryo.

Types

The simplest type of muscle is the **involuntary, nonstriated cell,** which is made up of an elongated cell with a centrally placed nucleus. The adjective *involuntary* says these cells are not under the control of the will, while *nonstriated* is used because there are no cross-markings. These simple muscle cells are found in the walls of the gastrointestinal tract, bronchial tubes, urinary passages, womb with its tubes, smaller arteries and veins, tubes leading from the various glands, attached to the shaft of the hair, and so forth, as will be noted in the various special sections.

The next type of muscle is the **involuntary striated cell,** as found in the heart. These cells are differentiated from the ordinary involuntary muscle cell essentially by the fact that cross-striations are demonstrable when the light under the microscope is cut down or with the ordinary stains.

The most highly developed type of muscle is the **voluntary striated fiber,** as found in the bulk of the muscles of the body. These are collections of muscle cells held in a strong fibrous sheath, the number of cells varying with the length of the particular muscle fiber. The characteristic feature of these muscle fibers is that the cytoplasm of one cell is not marked off from the cytoplasm of the next. These muscle fibers in man may reach a length of three to four inches, terminating by attaching to the white connective tissue in the interior of the muscle. In the embryonic fibers the nuclei lie in the center, but in the fully developed fibers they lie near the sheath covering. These fibers show the characteristic cross-striations under the microscope, on decreasing the illumination or with the ordinary stains. Each muscle fiber tapers to a point at its ends and connects with the white fibrous tissue framework of the muscle. The individual muscle fibers are wrapped with others into primary bundles, the primary into secondary, and so forth.

When any muscle fiber or cell contracts, the individual fiber or cell becomes shorter and thicker just as the muscle as a whole.

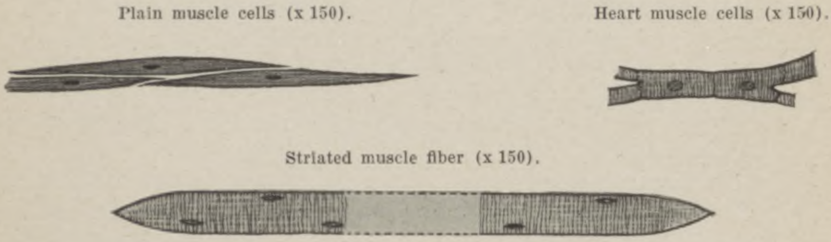

Fig. 6.

Development

Muscle cells of the various types are formed early in embryonic life and increase in size and power as growth proceeds. No new muscle cells or fibers are formed normally after the birth of the embryo, although if called upon to perform extra work, the individual cells may increase in size and power. If destroyed by accident or disease, muscle cells are replaced by the less highly specialized white fibrous tissue, resulting in the formation of a scar. The increase in size of an individual cell is known technically as hypertrophy, whereas if the extra work causes an increase in the number of the cells, as, for example, in the epithelium or fibrous tissue, it is known as hyperplasia.

Attachments

The involuntary muscle cells may attach at both ends to white fibrous tissue, which, however, is not attached to the bones. The voluntary muscle fibers are ordinarily attached via white fibrous tissue to the bones of the body at both ends, hence are often known as skeletal muscles. These strands of white fibrous tissue may be long or short. When these strands are long and running parallel, are compacted into a rounded or flattened cord, they are spoken of as **tendons,** or popularly sinews. When the muscle ends in a broad flat sheet with the white fibers paralleling each other, this flattened out tendon is known as an **aponeurosis.** The word aponeurosis states that it is derived from a nerve and is historically interesting as it shows the confusion existing before the introduction of the microscope between nerves and tendons. This confusion was due to the fact that both are white in color and tough in texture. The gross appearance and the microscopic construction of aponeurosis and fascia are very similar, but the distinction between the two must be kept clear.

Origin and Insertion

The fixed point on the bone from which a muscle arises is known as the origin, while the part of another bone on which it pulls is known as the insertion. When a muscle contracts, the point from

Fig. 7.—Diagram of lever action.

which it acts, or origin, is held firm, while the point on which it acts, or insertion, is drawn closer to the origin. Logic demonstrates that a muscle never arises and inserts on the same bone, for if so it could produce movement only by breaking the bone. Muscles arise on one bone and frequently pass over the next bone or bones to their insertion. Under certain extraordinary circumstances, for instance, a man walking on his hands, the origins and insertions of the muscles may be temporarily reversed. The terms origin and insertion are applied anatomically to the ordinary fixed and moving points.

Lever Principle

A simple principle of mechanics may justly be referred to here on account of its application to the origin and insertion of muscles. The diagram shows bones at a right-angle and brings out the short versus the long lever principle.

In diagram A. C. = long lever = great strength but speed no greater than muscle contraction.

A. D. = short lever = less strength, but greatly increased speed.

The muscular attachments of the body make use of the short or long lever principles according to their various needs.

Counter Action

Normally when a part of the body is moved by muscular action not only the active group contracts, but an opposing group contracts also, only in a much lesser degree. The object of this phenomenon is to steady the part so that it may move evenly. As a result it follows that if any group of muscles is injured or otherwise rendered incapable, not only is their action hampered or destroyed as the case may be, but the action of the opposing group is materially interfered with.

CHAPTER V

BONES AND JOINTS

BONES (OSSA)

Bones form the supporting, and in case of the skull, chest and vertebral column, the protecting framework of the body. The presence of a bony endo-skeleton separates the higher from the lower animals, the vertebrates from the invertebrates (endo = inside). A bone properly prepared for museum purposes is materially lighter in weight than one of equal size freshly removed from a cadaver. This is due to the fact that living bone in addition to its lime salts contains white connective-tissue fibers, marrow, body fluids and the bone cells. Such substances as a matter of common knowledge would spoil unless protected by an antiseptic of some kind. For the purposes of dissecting room models, these structures are encouraged to decay and then the bones are boiled in strong soaps to remove the last traces of organic matter. The white fibrous tissue framework remains, but even this can be destroyed by prolonged baking in dry heat. If these fibers are destroyed, bone becomes very brittle.

Pliability versus Brittleness

A bone so prepared is the product of formerly living bone cells, but it itself, strictly speaking, never was alive. The salts which were deposited in a connective tissue framework to give the hardness to the bone are chiefly calcium phosphate, with a minor admixture of other earthy salts. So our conception of the body being made up of cells is to be modified on account of the occurrence of various types of intercellular substances (inter = between). These deposited salts may be dissolved out by acids and then we have the absolute reverse of the above picture, a perfectly pliable bone made up of connective tissues and containing bone cells.

It is a matter of common knowledge that the consistency of bone varies normally according to the age of the individual. In youth the bones are relatively very pliable, as is borne out by the occurrence of green stick fractures and the fact that the average child grows up without breaking all the bones in his or her body. Anatomically this pliability is due to the relatively greater proportion of the connective tissue elements. In the adult bones reach their maximum strength, which is due to the full deposit of lime with the retention of vigor in the connective tissue elements. In old age the bones are characteristically brittle, probably due to a lessening of the strength of the white fibrous connective tissue elements.

Two diseases, or possibly the same process at different periods of life, due to an inefficient, one-sided nourishment of the body, cause a reabsorption of the deposited lime out of the bones. Under such circumstances the bones become excessively pliable and if weight is

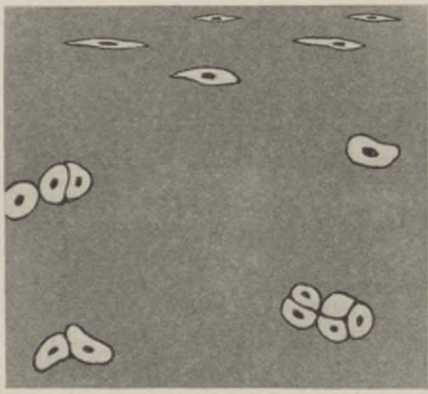

Fig. 8.—Cartilage (x 200).

put on such bones various types of bending deformities result, such for example as bowlegs. During the first few years of life this condition is known as rickets (rachitis), whereas the nowadays rare disease of adult life is known as osteomalacia (bone-softening).

Cartilage

The portions of the embryo, which will eventually become the bony skeleton, are first differentiated by the formation of cartilage. Cartilage is a connective tissue, and like the other connective tissues is derived from the mesoderm. Cartilage is popularly known as the covering over the ends of the bones of the higher animals at the joints. As to its physical characteristics, it is bluish white in color, semitranslucent, possesses considerable elasticity, and while it offers resistance is readily cut by a sharp knife. Cartilage has a very complicated chemical structure, and is not strictly a living structure, but is deposited and controlled by living cartilage cells. During the period of active growth the cartilage cells actively undergo mitotic division, but in adult life lie dormant unless called into activity by injury of some kind. Fine passageways, which can only be brought out by special staining methods, allow the body fluids to circulate about these cells. These passageways are known as **canaliculi,** the word meaning diminutive canals. Cartilage in the embryo is characterized by the great number of cells as compared with the **hyaline cartilage** of the adult (hyaline = glassy). Very commonly white connective tissue fibers are woven in the cartilage, which gives greatly increased strength, known as **white fibrocartilage.** At other places yellow elastic fibers are also added and the resultant type is known as **yellow elastic fibrocartilage.**

Classification

Bones are classified as long, short, flat or hollow according to their preponderant characteristics. The development of a typical long bone will be followed through in detail, bearing in mind that the same principles, although not so readily diagrammed, control the formation of the other bones of the body.

Gross Development

A long bone is first laid down in an embryonic form of nonfibrous or hyaline cartilage. About the eighth week of embryonic life the calcium salts begin to be deposited at the center of the bone, which then becomes known as the **primary center of ossification** or bone-making. This process gradually progresses from the center, until at the time of birth a small shaft exists running nearly the whole length of the bone. This shaft is continuously added to at its outer circumference by the deposit of bone, while at each end the cartilage remains unaltered until just about the time of birth. Then varying somewhat with the different bones, the **secondary centers** of ossification appear in these end pieces. These two end parts are known as the **epiphyses,** while the shaft is known as the **diaphysis** (epi = upon; di = between). Cartilage exists therefore at birth between the diaphysis and the epiphyses and remains throughout the period of bony growth, roughly twenty-odd years. New bone is being constantly formed at the diaphysis-epiphyseal junction throughout the period of growth and it is by this process that increase in the length of a bone is brought about. The cartilage disappears and the junction of the shaft with the two end pieces becomes solid bone at the end of the growth period. If the cartilage persists throughout life, the pieces are considered separate bones with a semijoint between them. If disease destroys the epiphyseal cartilage during youth,

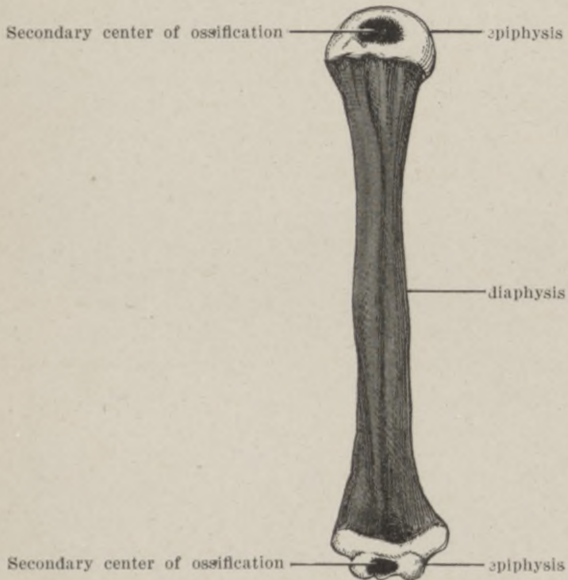

Fig. 9.—Bone development.

the increase in length of the bone involved is irretrievably lost. These facts of development have a marked influence on the character of bone injuries during childhood.

Very commonly the epiphysis is not one piece, but is eventually made up by the coalescence of smaller pieces. Other marked projections on the adult bone are commonly formed in the same manner as the epiphyses, developing later and fusing earlier than the main end pieces. As a rule the later in life the appearance of a tertiary center the earlier it coalesces with the main shaft.

Microscopic Development

The preceding discussion should have made clear that bone is made up of two essential constituents, to-wit, a white fibrous connective tissue framework in which lime salts are deposited. Cartilage is only a preliminary structure in bone and is invariably absorbed before or during the time that bone is being developed. The cells that make the connective-tissue framework are known as **fibroblasts**, while those controlling the deposit of lime are **osteoblasts** (blast = makers of). During the period of normal growth and eventually during the repair of fractures or following other bone injuries, these two classes of cells can be distinguished microscopically. During the growth process these cells are constantly producing new fibers

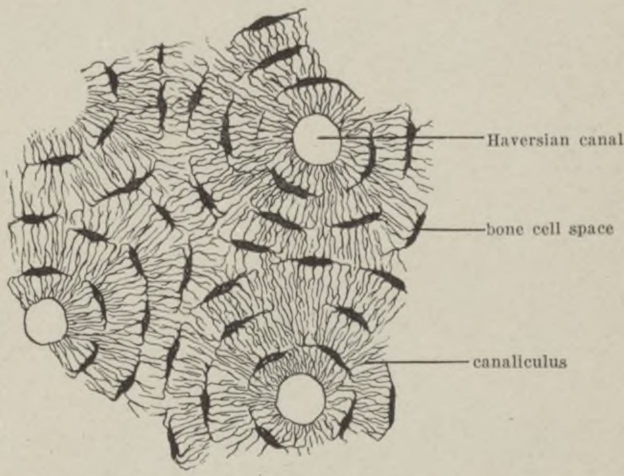

Fig. 10.—Compact Bone (x 200).

and new bone, adding it to the outer circumference of the shaft or at the diaphysis-epiphyseal junction as the case may be. From time to time blood vessels, fibroblasts and osteoblasts are covered over from the outer side and consequently built into the substance of the bone. These blood vessels are therefore open tubes of microscopic size running the long axis of the bone and are named the **Haversian canals.** Blood vessels are also built in at the diaphysis-epiphyseal junction, but in this area without regularity of arrangement. The fibroblasts and osteoblasts carry on the process of bone building inside of these large primary canals and gradually fill in the space from the outer surface inwards until there is only space left for the vessels. During this process the osteoblasts, about equally spaced, are caught in the bone and then become known as the bone cells. Very small canal spaces are left open in the bone, known as **canaliculi,** which allow body fluids to nourish and carry off waste from the bone cells. These bone cells lie semidormant unless called into activity by injury or disease. After the period of growth a stronger inner and outer layer of bone, with bone cells but no Haversian canals, is laid down, known in connection with the shaft as the inner and outer circumferential lamella (thin flat plate). The main bundles of white fibers of the shaft run the long axis of the bone, but other bundles cross at right angles. The growth process is essentially the same at the circumference of the shaft and at the diaphysis-epiphyseal junction, although the process, being more regular, is easier to follow in connection with the shaft.

The skull bones covering the brain develop a distinct fibrous framework in their cartilage a considerable time before the osteoblasts begin to deposit the lime. As a white fibrous framework is always laid down before lime is deposited, the only peculiarity of this occurrence is the time element. It is known as intramembranous bone development.

Tubular Structure

During the process of growth the body makes use of a well-recognized principle of mechanics. If the bones were simply added to at its circumference, it would become a solid rod. But weight for weight physics has demonstrated that a round tube is very materially stronger than a solid rod. The body produces the tubular structure of bones by a type of cells known as **osteoclasts** (clast = to break down). These osteoclasts live inside the bone and during the process of growth eat away the innermost layers of the shaft as new outer layers are formed. Through the agency of these same cells the broad ends and projections of bones are hollowed out, so as to produce lightness with the preservation of the requisite amount of strength. The architecture of these porous textured parts of the bone is well adapted to withstand probable injuries, while at the same time weight is minimized. The porous textured portions are known as **spongy** bone, while the large cavity extending throughout the length of the bone in its interior is known as the **medullary** or marrow **cavity.** The solid appearing portions of the bone, which, however, possess the microscopic Haversian canals, etc., are known as the **compact** bone.

Projections

Bones have various projections which are caused by and serve to give firm attachment to the muscle tendons. The more powerful the muscle, other things being equal, the more marked the bony protuberance. If these projections are sharp they are generally known as **spines**; if blunt and knotted, as **tuberosities** (tuber = root). Large rounded prominences in the neighborhood of joints, which serve to make larger opposing surfaces, are generally known as **condyles.** The sharp projections raised up from the condyles by muscle attachments are generally known as epicondyles. The term ridges, grooves, lines, and so forth, used in description are self-explanatory, while variations in naming will be considered in the regional divisions.

Vessels and Nerves

Bone has throughout life a system of arteries and veins. During the period of growth the necessity for a liberal supply is very obvious, but after the bone is once completed to its adult condition the vessels have comparatively little to do except in case of injury or disease. The main vessels of a long bone enter about the middle of the bone through a round opening known as the **nutrient foramen** (nourishment window). The two main subdivisions go in opposite directions towards the epiphyses, where they join with other small vessels entering near the ends of the bone. The blood circulates through the Haversian canals and the irregular spaces of the spongy end portions. Sensory nerves follow along with the vessels for the supply of the bone.

Cross-sections of a living shaft bone show the cancellous ends filled with a soft material known as red bone marrow (medulla ossium rubra). The red bone marrow has to do with the production of blood and, as it is only accidentally, as it were, in the bone, will be considered with the blood system. Yellow bone marrow, a loose fatty layer which fills up the medullary cavity, has no special functional importance (medulla ossium flava).

JOINTS (ARTICULATIONES)

Classification

Joints, or articulations, are specialized anatomic structures developed for the purpose of allowing motion between the bones. As a matter of common knowledge the range and character of the motion allowed at the different joints varies materially. The **diarthroses** are the freely movable type, the commonest and most important in the body (di = between, referring to the space between the bones). The **synarthroses** is the term applied to those joints which can take up the shock of blows but have no real motion (syn = together). This type of joint is found essentially in the suture lines of the skull, as will be detailed in the regional consideration. The **amphiarthroses** is the term applied to those joints which possess a very limited range of sliding motion (amphi = partaking of the character of both). In the B. N. A. these amphiarthrodial joints are not given a separate grouping, but are considered a subdivision of the diarthroses. In this case, however, this book will follow the many anatomists of standing who refuse to accept the change from the older classification.

Freely Movable Joints

In the class of freely movable joints, three distinct types occur: The ball and socket, the hinge, and the gliding. The shoulder and hip-joints are of the freely movable ball and socket type (enarthrosis). The hinge type (ginglymus) is best represented by the elbow and ankle joints, which possess a wide range of motion but only in one plane. Very many joints of all parts of the body allow a limited range of motion in all directions, and these are of the gliding type (arthrodia). Innumerable modifications of these types of freely movable joints occur, as will be detailed in the regional considerations.

The amphiarthrodial type is not popularly recognized, but makes up a group midway between the gliding type of diarthrodial joints and the synarthrodial joints.

Development

The cartilages of the bones are joined together in early embryonic life by white fibrous tissue. Early in embryonic life the **joint cavity** (cavum articulare) forms in this connective tissue layer, at no stage of its development being connected with the surface of the body. The interior of the joint cavity is lined by a layer of endothelial cells, which are derived from the mesoderm (endo = inside; thelium = covering). These cells form a single flat pavement layer and, being perfectly smooth, functionate by reducing friction to a minimum. During developmental stages this endothelium is said to line the whole of the interior of the joint cavity, but after birth the endothelial layer disappears from the opposing bearing surfaces. A layer of hyalin cartilage persists over the ends of the bone at the joint, which serves to give a perfectly smooth surface and also, to a certain extent, to take up shocks. Surrounding the joint cavity and attached firmly to both bones around the circumference are bundles of white connective tissue, which make the **capsular ligament** (capsule = surround). The thickness and strength of this capsular ligament varies according to the vigor of the individual and the joint in question, but is everywhere strong. At various points, as required by the exigencies of the special case, the capsular ligament becomes thickened, these thickened portions of the capsule being known as the **ligaments** of the joint. In the recesses of the interior of the joint cavity lie groups of **synovial glands**, which pour into the joint a thick, clear lubricating fluid. Following accident or disease this synovial fluid may be increased or decreased in amount. Judging by analogy with other internal body cavity secretions, synovial fluid is probably being continually secreted and reabsorbed.

The synarthroses do not possess joint cavities, while most amphiarthroses have cavities but usually of a poorly developed type.

Dislocations

The bones are held together at the joints by various factors. In the first place the strength of the capsular ligament is a very obvious and important factor. Great support is given to the joints by the muscles, which pass over the joint and tend to hold the bones in apposition. Still another factor is the occurrence of a vacuum in the interior of the capsular ligament. This suction resistance holding the bone together varies with the size of the joint cavity, but may be demonstrated to be considerable in the larger ball and socket joints. These three factors offer great resistance to the tearing apart of the bones, known as dislocation or luxation. Where these resistance factors, as a matter of practical experience, most often fail to prevent dislocations will be noted in the regional considerations.

CHAPTER VI

BLOOD AND LYMPH VESSELS

BLOOD VESSELS (VASA SANGUINEA)

The vessels which carry blood away from the heart are known as **arteries** (arteriæ), while those carrying blood back to the heart are known as **veins** (venæ). While arteries ordinarily carry red oxygenated blood and veins blue nonoxygenated blood, there are exceptions, which will be detailed in connection with the study of the heart. A system of very small vessels, known as **capillaries**, connect up the smallest arteries with the smallest veins. That the medical profession until the discovery of Harvey, in 1628, had not known of the circulation of the blood seems extraordinary to a present-day student. This lack of knowledge was in great part due to the fact that capillaries are microscopic in size and therefore are not visible to the unaided eye.

Circulation

The circulation of fluids exists in all animals and plants throughout life. It is by means of this circulation system of distribution that nourishment in its broadest sense is carried to distant parts of the body and waste products of life are gathered up to be thrown off. To accomplish this result the circulating fluids must therefore reach every living cell of the body. The absolute stopping of the circulation of animals, persisting for a variable length of time, determines the death of the individual. Many of these body cells, however, if brought into contact with the circulation of another individual of the same kind are still viable. After a short time, varying with the character of the cells, all cells cut off from the circulation die.

Blood (Sanguis)

All the higher, more complex animals have some type of muscular pump to keep up the circulation, which is known as the heart. Its general plan, similarities, and dissimilarities in the various animals and man will be noted in the special division devoted to that organ. The blood is made up of water in which are dissolved certain elements of nourishment and waste products, the **plasma,** and certain formed elements, the **corpuscles.** The relatively high percentage of albumins gives plasma its familiar viscid, sticky consistency. The plasma in man is approximately half filled by very highly specialized corpuscles, the red blood corpuscles, or **erythrocytes** (erythro = red). These are biconcave, round discs and are not cells in the ordinary sense, inasmuch as normally in the circulating blood after birth they have no nuclei. These corpuscles specialize on the functions of carrying oxygen to the tissues, giving it up to the cells, and return as blue blood carrying back carbon dioxide. This carbon dioxide is thrown off in the lungs and oxygen again taken up. These red blood corpuscles are being constantly destroyed in the body and are replaced by new corpuscles formed by nucleated cells in the red marrow of the bones. Besides these erythrocytes, white blood cells, or **leucocytes,** exist normally in the blood in a small percentage, averaging during health about one to every seven hundred erythrocytes. These cells have nuclei and are being constantly produced and destroyed, as will be detailed later on. They not only exist in the blood but possess the power of working through the capillary walls into the tissue spaces and therefore are often called the wandering cells. They functionate as protectors and scavengers of the body.

Capillaries

The inner lining of the entire heart, artery, vein, and capillary system is made up of a single layer of endothelial cells. Just as in the interior of the joints and in all other parts where they are found these cells form a perfectly smooth, shiny surface, which serves to reduce the friction to a minimum. Capillaries are made up simply of this layer without any other coat.

Large Arteries

The heart forces the blood at great speed and under high pressure into the main arterial trunks. This pressure is held by a thick, very firmly woven coat of yellow elastic fibers, which coat gives the yellowish tinge to the interior of a freshly sectional larger artery.

Spaces are left open in this layer, which allows the body fluid to care for the dormant lying cells existing among the elastic fibers. The elasticity of this layer causes the vessels to contract down on the column of blood, producing a more continuous flow. If for any reason the pressure of the blood mounts extra high and this condition is maintained over long periods of time, this elastic coat becomes irreparably injured. This condition is known as arteriosclerosis (sclerosis = hardening). Later on lime salts may become deposited in this coat, as is very common in degenerated tissues, and on account of the movements of the body semijoints are formed, causing the bead-like feel of a calcified artery. The inner endothelial coat of the blood vessels is known technically as the intima, the important middle coat as the media, and there is an outer coat of white connective tissue known as adventitia.

Arterioles

This anatomic structure is maintained along the arterial system, decreasing quantitatively down to the very smallest arteries, which are known as arterioles (oles = diminutive ending). These arterioles have little connective tissue in their walls, but its place is taken by circular plain muscle fibers, which are under the control of the involuntary nervous system. When any part of the body on account of activity requires a more liberal supply of blood, the muscles of the arteriole wall relax and more blood flows to the part. Conversely, when the circular muscles of the arteriole wall contract strongly, less blood flows to the part supplied by the narrowed vessels. When the muscles of the arteriole wall are tightly contracted the blood in the interior of these vessels can not be seen, but when the muscular walls are relaxed the red color of the arterial blood shows distinctly through the thinned-out wall.

Veins

After its passage through the capillaries the blood is gathered into **venules**, which, like the arterioles, have circular muscle fibers in their walls. The venules run together into larger veins, the larger veins into others still larger, and by progressive junction all the blood of the body pours into two large veins, which empty into the heart. The walls of the veins, having much less pressure to sustain, are materially thinner than the corresponding arteries. They possess practically no elastic tissue, but are made strong by woven, white fibrous connective tissues. The walls of veins are white, but when distended the characteristic dark blue color of venous blood is transmitted through the wall. Veins, on account of their thinner walls, are much more easily torn than arteries, the walls of even the largest veins being so thin that the color of the dark venous blood shows distinctly through.

Rate of Flow

The same amount of blood during any prolonged fixed time must flow through the main artery, the capillaries, and the main veins. For if this condition were not fulfilled, all the blood of the body must eventually accumulate in one division. The combined cross-section of all the capillaries is several hundred times that of the main artery and veins at their connection with the heart. Therefore the blood flows very slowly through the capillaries, allowing ample time for the interchange between the blood and the tissue cells. The flow of blood through the main artery and veins, on the other hand, is very rapid. For example, whereas the blood flows in the main arteries at the rate of at least a foot per second, in the capillaries red blood corpuscles may be noted to wander leisurely across the microscopic field.

Thickness of Walls

It may be accepted as a universal proposition in anatomy that the strength of any portion of the body is no greater than the ordinary requirements of the part, plus a fair factor of safety. The blood in the capillaries is under a high unit pressure, but due to the extremely small bore of the individual capillary the actual total pressure on the walls is easily cared for by the single layer of endothelial cells. Fact is, under abnormal conditions the pressure in the capillaries may rise six times as high as normal without rupture of the vessel. Following this same principle, with equal unit pressure, the larger the caliber of a vessel the thicker must the walls be in order to insure proportionately equal strength. This law of physics explains the anatomic finding, which is that the larger the artery or vein the thicker and stronger are its walls.

Anastomosis

It is obviously important that the circulation be maintained under all circumstances. The big safety factor in the vascular system, by which with the main vessels blocked circulation is nevertheless maintained, is known as anastomosis (ana = again; stoma = mouth). If a direct route is blocked by accident or disease, the blood flows out of one of the branches before the blockade, through smaller connecting arteries and into the main vessel beyond the blockade. At first this makeshift, collateral circulation, although amply sufficient to maintain life, is not really efficient. If the blockade is maintained over a longer period of time, the anastomosing vessel becomes larger and fully equal to the maximum requirements. Anatomists formerly believed that parts of the body, the brain and heart for example, did not possess anastomoses, but the newer researches have apparently proved this to be an error of observation. Our present knowledge leads us to believe that anastomosis is everywhere present throughout the vascular system, both on the arterial and venous side.

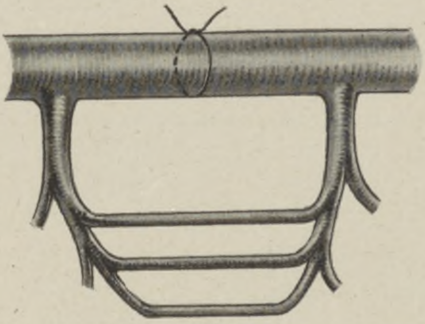

Fig. 11.—Anastomosis of blood vessels.

Secondary Position of Vessels

In embryonic life the main arteries accompany the main nerves, the segmental artery, vein, and nerve being wrapped up in one connective tissue bundle. The nerves maintain their position unchanged throughout life. But the arteries and veins, by a process through which the anastomosis becomes large while the main vessel becomes the anastomosis, can readily and do often change their positions. That certain vessels in some individuals do and in others do not change from their embryonal position is the reason back of the frequently found variations from the normal found in actual dissection. Some examples and details of this occurrence will be noted in the regional considerations.

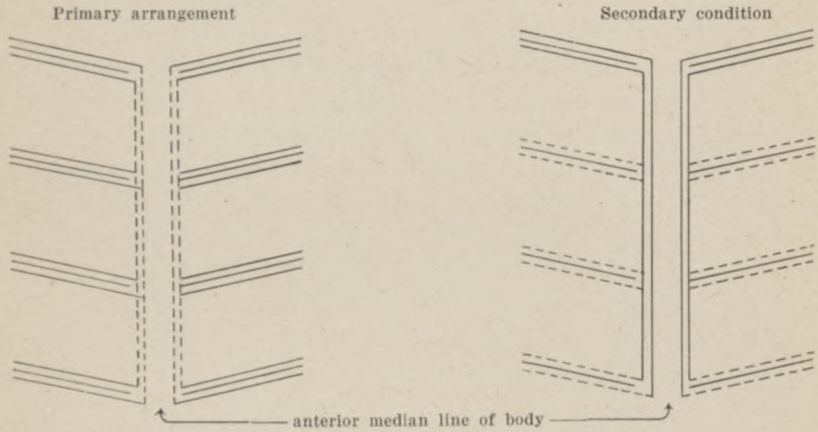

Fig. 12.—Primary versus secondary positions of arteries and veins. Solid lines in diagrams are arteries, veins and nerves. Dotted lines in diagrams are anastomosing arteries and veins.

General Location

The main arteries and veins ordinarily accompany each other and are ordinarily named according to the region they are traversing. These vessels are always under the deep fascia, usually in the most protected region and very commonly down deep in close proximity to the bone. With but a single exception the vein does not lie directly between the artery and the bone. It is obvious that such a relation would tend to obstruct the return of venous blood. Smaller arteries are accompanied by a pair of veins on opposite sides, which are known as the **venæ comitantes** (comitans = accompanying). Where a part is fleshy the artery and vein ordinarily lie deep down from the surface, whereas when the muscle gives way to tendon, as, for example, at the elbow, wrist, knee, or ankle, the artery lies nearer the surface, or, more accurately phrased, the surface lies nearer to the artery.

Superficial Venous System

Aside from the system of veins just discussed, an entirely distinct system is found in the subcutaneous fatty layer over the whole body. This venous system lies outside of the deep fascia and is known as the superficial venous system in contradistinction to the deep venous system inside of the deep fascia, the two systems anastomosing freely. The superficial venous system has no analogous arterial system. The cause for the existence of this superficial venous system is that when the muscles and fascias are drawn tense the resistance within the deep fascia increases. This pressure does not materially influence the flow of blood in the arteries, but proves a great handicap to the return flow of blood in the veins. The venous blood then escapes into the superficial venous system, is carried around the obstruction and is consequently enabled to return unobstructed towards the heart. Inasmuch as the blood in these superficial veins is in thick-walled vessels with limited surface, the heat radiation factor is practically negligible.

Vales in Veins

Most veins of both the superficial and deep venous systems possess valves, which are arranged so as to prevent the reflux of blood when the vein is compressed. The valves are made up of white fibrous tissue covered by endothelium, and blend around their outer circumference with the connective tissue walls of the veins. When the venous blood is flowing towards the heart these valves are open, but if the flow be reversed the valves close and prevent backflow. Movements of the body tend therefore to drive the blood on towards the heart. The only veins lacking valves completely are the two largest veins of the body (vena cavas superior and inferior), which empty directly into the heart. This peculiarity of the largest veins presumably has a functional reason for its existence, even though none has been established.

LYMPH VESSELS (VASA LYMPHATICA)

A superficial cut through the epidermis of a living individual is rapidly filled up with bright red blood. This comes from the capillaries and soon stops as the cut ends of the capillaries become filled with a blod clot. If the blood clot be wiped off with a moist cloth, taking care not to reopen the vessels, the surface becomes covered with a yellowish tinged sticky fluid, which is lymph. Lymph is very similar to the plasma of the blood with all its red corpuscles removed, but is not exactly the same thing. The capillaries in health do not allow red blood cells to escape into the tissue spaces, but allow water containing certain salts and foodstuffs, including albumins, to escape through their walls. White blood cells also normally work their way out of the capillaries into the tissue spaces and hence receive their name of wandering cells. A striking and popularly known illustration of this fact is in the formation of pus. This lymph is being constantly secreted by the capillaries and constantly makes its way back into the veins. It flows through the tissue spaces, then through small collecting vessels, and eventually into one large trunk, which empties into a large vein at the base of the neck. The lymphatic vessels anastomose freely and the main trunks accompany the veins of the part. All the living cells of the body must be bathed in lymph, as it carries nourishment to them and takes away their waste products. It is therefore an extremely important element in the circulation.

If a vein is blockaded so that the pressure in the capillaries rises high, so much lymph is formed that the vessels can not carry it off with sufficient rapidity and the part becomes overfilled with lymph, giving a white color and a doughy feel. This condition is known as circulatory dropsy.

Lymph Glands (Lympho-glandulæ)

The lymph vessels are fitted with valves, so arranged that all the movements of the body tend to drive the lymph onward towards the veins. Every lymph vessel pours its lymph through a type of filter, known as a lymph gland or node. These lymph glands check or attempt to check the entrance of foreign bodies, or of bacteria, or of cancer cells, into the general circulation. Lymph glands are normally only slightly firmer than fat in consistency, are bean-shaped and about one-eighth of an inch in their greatest diameter. These lymphatic glands are found sometimes solitary, more often grouped around the main veins in convenient localizations. But the action of the lymph glands is more than a mechanical filter, for if called upon to resist invasion of the general blood they increase in size and functional ability. It is only when this lymphatic defense is broken down that bacteria or cancer cells can enter the general circulation via the lymph.

CHAPTER VII

NERVES (NERVI)

Microscopic Structure

Nerves are highly specialized body cells, whose function is to carry messages from the brain or spinal cord out to the various parts of the body, or vice versa. Nerve cells are derived developmentally from the ectoderm, as will be detailed in connection with the consideration of the central nervous system. Most of them are relatively large cells, being commonly twenty times in diameter the size of a red blood corpuscle. They are characterized by sending out an **axis-cylinder process** and one or more **dentritic processes** (dentrite = small root.) The extraordinary feature of these axis-cylinder processes is the fact that they may be three feet or more in length, extending, for example, from the spinal cord down to the sole of the foot. All the other body cells previously studied, it may be well to emphasize, have been microscopic not only in width but also in length. A nerve cell, together with all its processes, is known as a **neuron.** Most all these nerve processes are enclosed in a very thin translucent sheath known as the neurilemma. Further, most axis-cylinder processes are surrounded by a thick covering known as the **medullary** or myelin **sheath,** which lies between the neurilemma and the nerve process, and presumably functionates as an insulator. The medullary layer is an intercellular substance, deposited probably through the activity of the nerve processes.

This medullary sheath is very delicate and is glistening white in color, which helps to give the characteristic white, shiny appearance to the ordinary nerve. The gross physical appearance accounts for the confusion between tendons and nerves which is so commonly found in old anatomic texts. A few nerves appear gray in color, due to the absence of a medullary sheath, nerve substance proper being gray. The axis cylinder processes covered by their medullary sheaths are wrapped together by liberal amounts of white connective tissue into bundles, which, on account of the connective tissue elements, possess very considerable tensile strength. A nerve of one-eighth of an inch in diameter containing several hundred thousand axis-cylinder processes yields a fair working conception of their average size in cross-section. The axis-cylinder process termi-

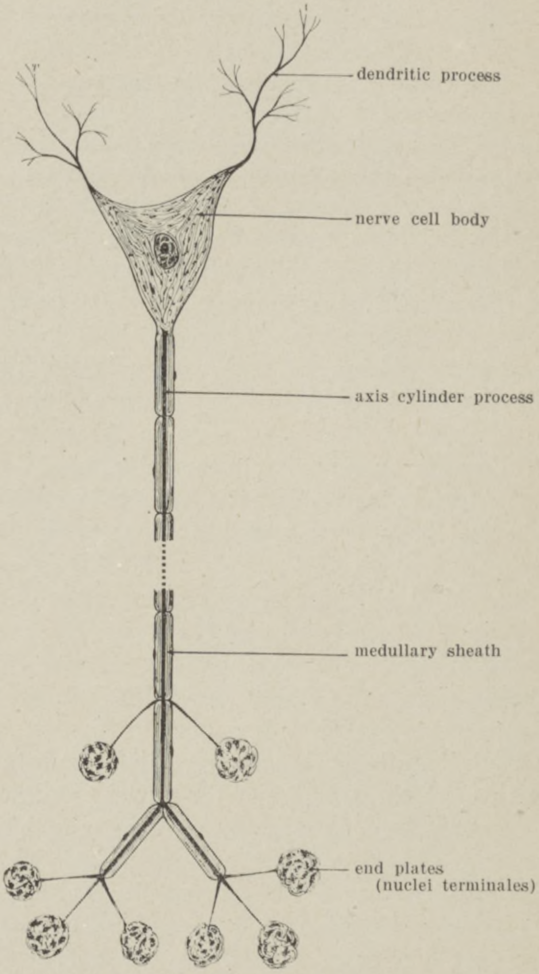

Fig. 13.—Diagram of a **Neuron** (x 300).

nates in some special type of end-plate in the skin or on a muscle fiber, or at some other terminal point. Each axis-cylinder process near its terminus commonly branches to a dozen or more of these bulbous **end plates** (nuclei terminales).

Systems

The Central Nervous System is made up of the brain and spinal cord, while the **Peripheral Nervous System** consists of the nerve processes leading from the brain and spinal cord to various parts of the body (peri = around; pherro = carry). The peripheral nervous system is divided into the peripheral nerves proper and the sympathetic nerves.

Peripheral Nerves Proper versus Sympathetic Nerves

The peripheral nerves proper control the voluntary activities of the body, while the sympathetic nerves control the involuntary activities, although minor exceptions to this rule will be noted in the regional considerations. Thus the sensory processes to the skin, fascias, muscles and bones, and the motor processes to the voluntary musculature belong to the peripheral nerves proper. On the other hand, the nerve processes to the various glands, all involuntary plain muscles, and the automatically regulating thoracic and abdominal organs belong to the sympathetic nerves.

The peripheral nerves proper are characterized anatomically by the fact that all cell bodies lie in the brain or spinal cord; that all processes are medullated after birth; and, further, that their processes make up the great bulk of the nerves, except those running to the various thoracic or abdominal or other special organs. The sympathetic nerves are characterized anatomically by the fact that many of their groups of cell bodies lie outside of the central nervous system; that many of their processes are nonmedullated throughout life; and that, although many of their processes follow along in the peripheral nerves proper, others run a separate course along with the fascial compartments of the blood vessels. The sympathetic nerve processes commonly stop several times or more en route to their terminations in a way-station of nerve cells, known as a **ganglion** (swelling). A ganglion is a collection of nerve cell bodies, hence gray, held together by connective tissue. Many more processes commonly leave these peripheral sympathetic ganglia than enter from the spinal cord side. Thus a multiplication of sympathetic nerves takes place, commonly a very great multiplication just before their termination, which does not occur in connection with the peripheral nerves proper.

Segmentation

The nerve supply of the body is very distinctly segmental in type and remains strictly in its embryologic relations throughout life, variations being extremely uncommon. Primarily these nerves were accompanied by an artery and vein, although, as was noted in the section on vessels, the artery and vein very commonly leave their primary positions. All the main nerve trunks lie under the deep fascia and ordinarily in the most protected positions. No segmental nerve ever completely supplies the corresponding body segment among the higher animals, some nerve processes from the segmental nerve above and some from the nerve below invariably joining the nerve trunk. This arrangement provides a safety factor against injury at the vertebral column exits and is known as the **plexus,** or weaving, of the nerves.

Repair

Nerves are very highly specialized cells and are not produced after birth. If an axis-cylinder process or dentrite is cut, the cell possesses the power of growing a new process. But if after a certain stage of embryonic life the nerve cell itself is destroyed, the damage is permanent, as no new cell can be produced.

PART II

REGIONAL ANATOMY

CHAPTER VIII

THE UPPER EXTREMITY

SHOULDER AND ARM

The part of the body composed of the shoulder, arm, forearm, and hand is known collectively as the upper extremity. The upper extremities obviously possess bilateral symmetry, one upper extremity being the accurate mirror reverse of the other. The upper extremities are further characterized by segmentation, as they are controlled, as will be detailed later, by the paired fifth, sixth, seventh, and eighth cervical and the first thoracic segmental nerves.

In any regional consideration of anatomy the bones are justly considered first, as they make up the supporting framework. Wherever the bones are not covered by muscles, or the muscle covering is thin, the projecting parts can be felt as landmarks under the skin and subcutaneous fatty layer. The relative position of other anatomic structures can then be estimated or even accurately determined. Bones vary in different individuals in regard to size, strength, and relative position, but by an examination of the corresponding opposite bone a fair estimate of the normal for the bone under consideration may be drawn.

In most quadrupeds, to whom anatomically, at any rate, man is closely related, three developmentally distinct bones are joined together to form the socket for the ball of the armbone. In man two of these bones of the shoulder girdle fuse into one, so that in the adult we have only two bones forming the shoulder socket, the **scapula** and the **clavicle.** The original coracoid bone becomes the **coracoid process** of the scapula (coracoid = like a raven's beak).

The bone descriptions should be supplemented by reference to the drawings in the anatomic atlases or reference books, or preferably to the actual dried specimens. Much help can also be gained by outlining the bones in the student's own body.

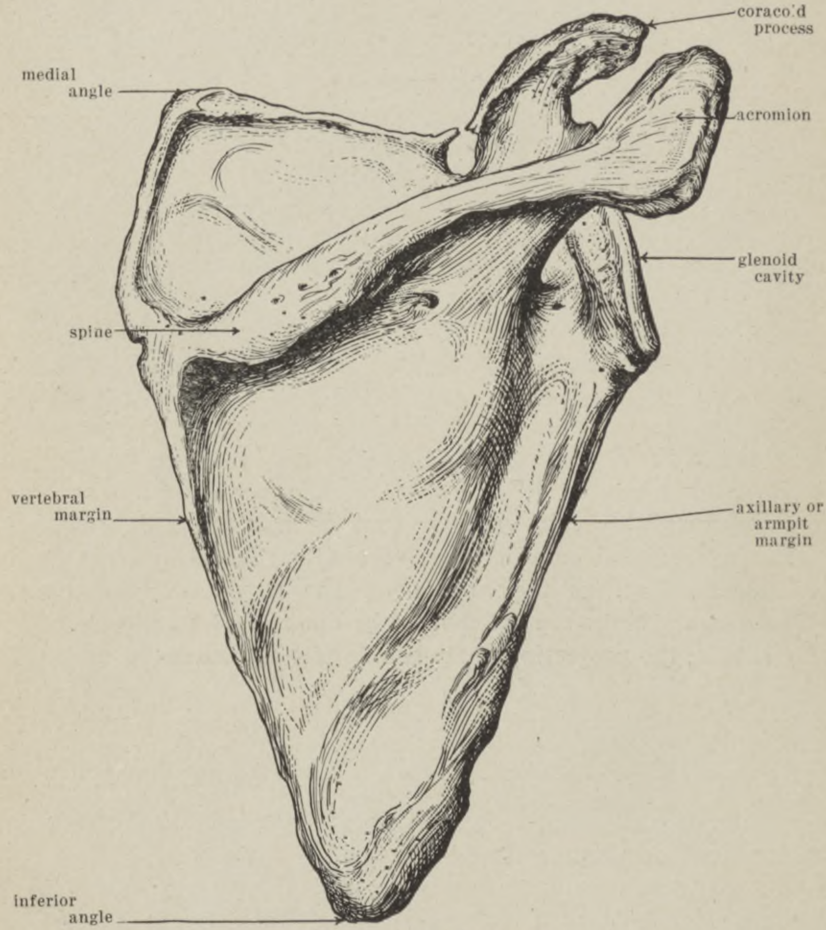

Fig. 14.—Right **Scapula**, dorsal surface.

Scapula

The scapula is a flat, triangular-shaped bone spread out over the upper part of the back of the trunk (scapula = spade). The back or posterior surface is generally known as the dorsal surface, whereas the front or anterior surface is known either as the ventral or costal surface (costa = rib). A heavy ridge runs horizontally across the dorsal surface about three-quarters of the way up. The free edge of this ridge, not being covered by muscles, is subcutaneous and therefore readily palpable. This ridge has been given the misnomer **spine** of the scapula, whereas logically it should be known as the ridge of the scapula. This ridge continues beyond the scapula, making a right-angled turn forward over the shoulder joint, and in this region becomes known as the **acromion** or acromial process (summit of the shoulder). The socket lying under the acromial process, known as the **glenoid cavity,** is the receptacle for the ball of the arm bone. Projecting forward and above the glenoid cavity is

Fig. 15.—Left **Clavicle**, superior surface.

the irregular strong **coracoid process,** which, like the acromial process, makes an arch over the scapular socket. The other names of the parts of the bone are explained on the diagram sufficiently for our present purposes.

Clavicle

The clavicle or, popularly, the collar bone, has a subcutaneous surface throughout, and consequently is readily palpable (clavicle = key). At its medial end it is attached to the sternum or breast bone, and at its lateral to the acromial process of the scapula. It is an irregularly rounded and, in its lateral third, flattened bone. Its middle third is materially smaller in circumference than its sternal and its acromial thirds. Its curves vary somewhat in different individuals, but can readily be followed just under the skin.

Humerus

The humerus is the strong, long bone of the arm (humerus = funny). It is characteristically like the general description of a typical long bone, being made up developmentally of a diaphysis and two epiphyses, and in the adult of a body or shaft and two extremities. The ball of the upper extremity of the humerus is known as the **head**, just below which lies the **neck**, the groove in which the capsular ligament of the joint attaches. The **greater**, or lateral, and the **lesser**, or medial, **tuberosities** are raised up by muscle attachments. The B. N. A. peculiarly uses the diminutive form tubercle instead of tuberosity, but this usage has not been followed, as it is not in keeping with the facts. The intertubercular sulcus or groove, containing one tendon of the biceps or two-headed muscle, runs between the greater and lesser tuberosities and continues several inches down the front surface of the humerus. The lips of the intertubercular groove are raised up by the aponeurotic insertions of strong muscles. The **epicondyles** are the inferior portion of the bone, widened out for articulation with the bones of the forearm.

Vertebræ

The vertebræ are the series of bones making up the vertebral column or backbone (vertebra = turn). The upper seven are called the **cervical** or neck vertebræ. The next twelve are named the **thoracic** or chest vertebræ, or sometimes improperly, because not distinctive, the dorsal vertebræ. These vertebræ are characterized by each having a pair of ribs, with notches where the ribs attach. Then follow the five **lumbar**, or loin, vertebræ. The next five original vertebræ in the adult are fused into one piece, which is held between the hip bones and is known as the **sacrum** (sacrum = sacred). Below the sacrum follows the **coccyx,** representative of the tail bones of the lower animals and made up until middle life of two separate tapering pieces (coccyx = cuckoo's beak). The larger upper bone of the coccyx is developed from one original piece, the lower of three or four parts fused into one.

Vertebræ are typically made up of a body (corpus vertebræ) and an arch which surrounds the spinal cord (arcus vertebræ). Extending back in the midline from the arch is a more or less sharp process, known as the **spine** of the vertebra. The tips of these spinous proc-

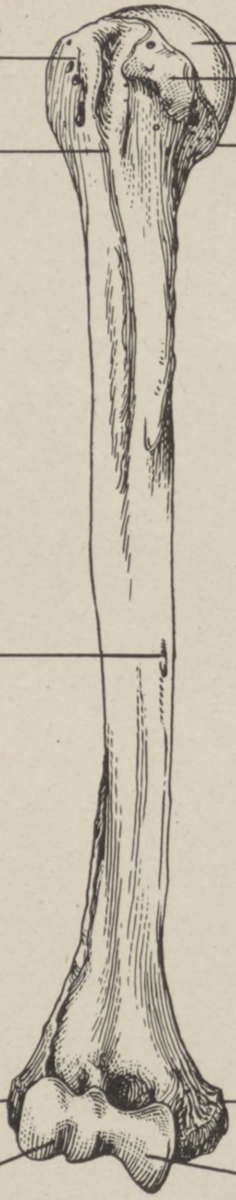

Fig. 16.—Right **Humerus**, anterior surface.

esses from the sixth cervical vertebra down to the coccyx are subcutaneous and therefore readily palpable. These spines should theoretically follow each other in a perfectly straight line, but as a matter of practice there is always some side-to-side deviation. By gentle manipulation of the spines it is ordinarily possible to determine the presence or absence of fracture of the arch of the vertebra. The characteristic signs of fracture are: Abnormal range

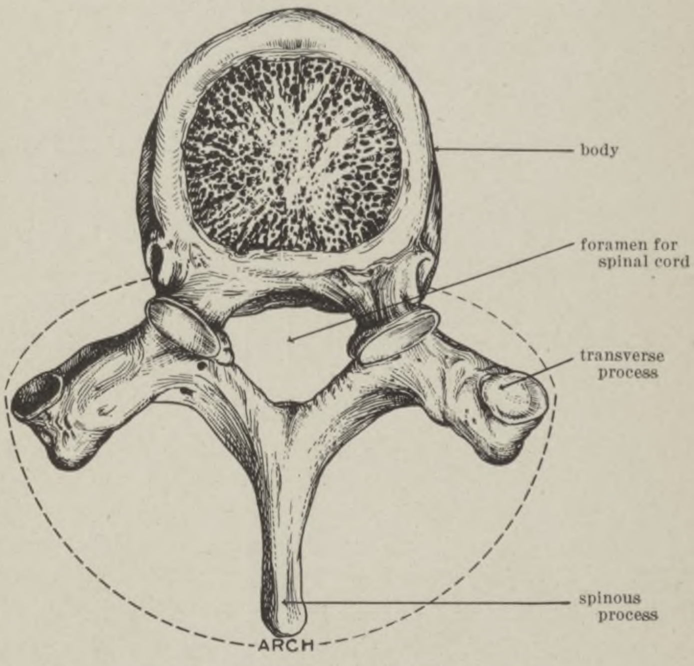

Fig. 17.—Typical thoracic **Vertebra**, superior surface.

of motion, grating and severe pain on movement of the part, and hemorrhage at site. The other features of the vertebræ are explained sufficiently in the diagram for our present purposes.

Dissection.—The body is to be laid on the table with the back region up, and preferably fixed by blocks under the body so that the whole area is stretched. The tips of the vertebral spines, the spine of the scapula with its continuation, the acromial process, and the clavicle are to be located under the skin. Also the ridge of the hip bone, which is technically known as the **crest of the ilium.** Then in spots the epidermis is to be scraped off in order to note its thinness and the pigment in the deeper layers. A cut is then to be made through the tough dermis in the middle line from the lower part of the skull to the sacrum. A two-inch long incision is then to be carried lateralward across the back part of the neck at its junction with the skull and a lower incision of about four inches length following the crest of the ilium. The dermis layer should be dissected off from the subcutaneous fatty layer. This is rather difficult for the beginner, at least, and can best be accomplished by holding the dermis evenly tense and shoving against the under surface with a sharp round-bellied knife. The dermis tends to slip out of the grip of even-teethed forceps, so that after a start has been made it is often very helpful to perforate the loosened part of the dermis for finger grips. Actual experience with, if possible, the aid of an experienced demonstrator is the only efficient teacher. If the under surface of the dermis is strictly adhered to, the surface will show evenly distributed pits. A very obvious advantage of sticking close to the under surface of the dermis is that the danger of destroying deeper parts is absolutely done away with.

During the progress of dissection the body should be prevented from drying out by wrapping it in cheese cloth, which should be kept soaked with water. An outer covering of oil cloth tends to keep the water from evaporating and consequently minimizes labor. If parts of the body should become too dry during the progress of dissection, they should immediately be immersed in a prolonged bath. If the drying has not progressed beyond a certain stage, this bath will restore conditions to the normal; but if the part has been allowed to mummify, it has become useless for dissecting purposes.

Subcutaneous Fatty Layer

Due to the evaporation of water out of the body the subcutaneous fatty layer is frequently found to be thinner than during life, while the action of the preservatives commonly used makes the fatty layer appear pale in color. If the body has lain on its back for a long time, however, the preserving fluids may gravitate in extra quantity into this loose layer. The fatty layer covers the whole back in average thickness, varying with the general stoutness. The larger fibrous tissue framework is microscopically visible surrounding the globules of fat, but in spite of this connective tissue the layer is not strong. This fatty layer contains the segmentally arranged posterior series of cutaneous arteries, veins, and nerves, and, in addition, a superficial venous system.

This arrangement should be noted in a general way as the subcutaneous fatty layer is dissected off from the deep fascia.

Fascia

The deep fascia over this region is moderately strong and should be noted to give a complete covering to the muscles, and to be continued between the neighboring muscles.

Muscles

The first layer is made up of two muscles, extending practically over the whole back.

The **trapezius** arises from the base of the skull and from the spines of all the cervical and thoracic vertebræ (trapezius = pair make a trapeze-shaped figure). The upper fibers run downward and forward to their insertion into the posterior surface of the acromial third of the clavicle, the middle fibers run straight to the medial surface of the acromion, while the lower fibers run upwards into the superior edge of the spine of the scapula. It acts as a raiser and also as a rotator of the shoulder.

The **latissimus dorsi** arises through an aponeurosis, extending from the lower six thoracic spines, all the lumbar spines, from the sacrum and the posterior third of the crest of the ilium (latissimus = broadest). Its fibers run with varying degrees of obliquity, pass the lower angle of the scapula as a contracted, much thicker mass, and continue through the posterior fold of the arm-pit to the humerus.

Dissection.—These two muscles must be cleared of their outer layer of deep fascia, in order that their constituent muscle bundles may be clearly seen. The aponeurosis origins, which look just like a deep fascia, should not be disturbed.

By dividing the trapezius muscle half-way between its origin and insertion, and turning the divided ends back, the deeper layer of muscles is brought into view.

The **rhomboids** arise from the lower four cervical and upper four thoracic spines of the vertebræ and run diagonally lateralward and downward to their insertion along the whole vertebral border of the scapula (rhomboid = parallel-sided figure).

The **levator scapulæ** runs from the transverse processes of the upper four cervical vertebræ and inserts as a rounded mass into the superior vertebral angle of the scapula (levator = to raise up).

Front of Chest

The body is next to be turned upon the back, and the front of the chest is to be considered. The subcutaneous border of the clavicle is readily felt, making a convenient surface separation between the front of the chest and the lower part of the neck. The coracoid process, although covered by muscle, can be felt by pressing just in front of and below the clavicle at the junction of its middle and acromial thirds. The ribs can be felt as bony landmarks, although covered throughout by muscles, while in the middle line the sternum or breastbone can be palpated.

Sternum

The sternum is a rather porous bone made up of three distinct parts, which are named according to their alleged resemblance to a dagger. These parts are the **manubrium,** or handle, the **corpus,** or body, and the **xiphoid** or ensiform **process,** or tip. A cartilaginous insert between the manubrium and corpus sections of the sternum allows a limited range of motion.

Costæ

Seven pairs of ribs are directly attached to the sternum by means of **costal cartilages,** and are therefore known as the true ribs (costæ veræ). The remaining lower five pairs of ribs are functionally independent of their attachment to the sternum and are therefore known as false ribs (costæ spuriæ). The costal cartilages of the eighth, ninth, and tenth ribs do join with the costal cartilages of the ribs above, but this slight connection is of distinctly minor practical importance. The costal cartilages of the eleventh and twelfth ribs end absolutely free and hence these are popularly known as the floating ribs. The costal cartilaginous inserts obviously serve to increase the elasticity of the chest.

The ribs, considered from above downwards, form segments of progressively larger circles. The little **head** of a rib forms a joint with the vertebræ, then follows a constricted portion known as the **neck,** while the great bulk of a rib is known as the **body.** The Latin word for head is *caput*, for little head is *capitulum*, for neck *collum*, and for body *corpus*. The bodies of the ribs are materially wider superiorly-inferiorly than externally-internally. The ribs can be felt

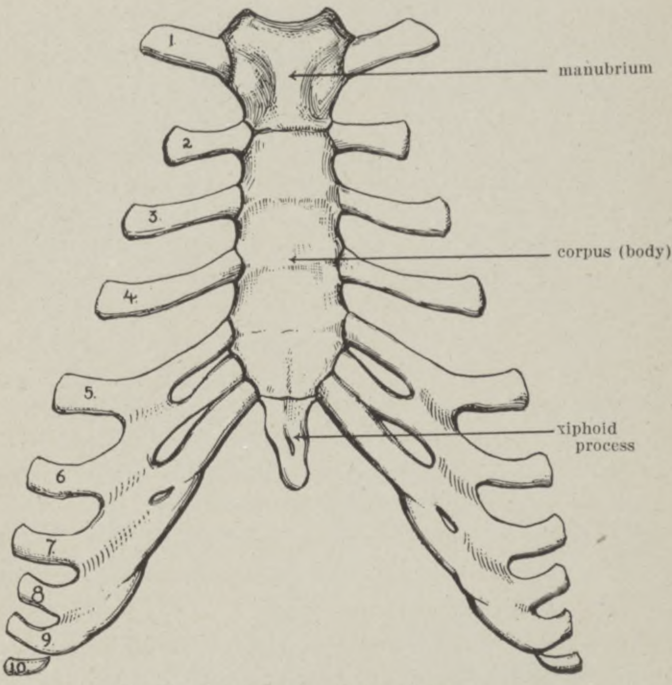

Fig. 18.—Sternum and costal cartilages.

best in the midaxillary line, as in this area they are only covered by a thin sheet of muscle.

Mammary Gland (Mamma)

The skin is of average strength and is only remarkable on account of the presence of the mammary or breast gland (mammary = adjective of mamma). These glands are paired and the nipple lies normally over the fourth interspace between the ribs, a relatively constant distance from the midline. Normally only one pair of these glands develop from the skin, but as an abnormality one or more extra pairs may occur in series as in the lower animals. They reach the height of their development during the child-bearing period of a woman's life and after that normally involute, that is, undergo retrogade changes. During pregnancy the gland lobules increase in size in conformity with the functional demand. The gland is divided by radially arranged fascial septa into compartments, which fact should always be taken into consideration in planning a surgical incision. The gland is embedded in the subcutaneous fatty layer and is held in position by strands of connective tissue attaching it to the deep fascia and to the skin. These attachments normally allow a certain range of motion in all directions to the breast. A unilateral, localized decrease in this range of mobility demonstrates a shrinkage of the connective tissues. When other causes of this shrinkage can be excluded, the presence of this sign is most suspicious of the contracting, scar-tissue forming type of cancer. The blood and lymph supply of the large female mammary gland comes in great part from the arm-pit region, but also as will be noted later from branches from inside of the chest wall. The lymphatic drainage assumes great practical importance in the temporary localization of the secondary cancer nodules in the lymphatic glands.

Structure of a Compound Duct Gland

The typical structure of a large compound duct gland, such as the mamma, will be outlined. The smallest subdivision of such a gland is known as an **acinus**, which is made up of a group of large secreting cells arranged around the termination of the smallest duct. The Greek word acinus means grape, and is here used figuratively to imply that each acinus has the same relation to the entire compound gland that each grape has to the bunch of which it is a part. In the case of some compound glands the smallest subdivision is known as an **alveolus**, this word stating that the smallest subdivision is hollowed out or saccular. The walls of these acini or alveoli are made up by a single layer of large cubical cells, which vary somewhat in structure and markedly in function in the various compound glands. A number of acini or alveoli are grouped together in a delicate connective-tissue capsule, making up a **lobule**, which is visible to the unaided eye (lobule = diminutive of lobe). Very commonly a great number of these lobules, which empty into a common duct, are grouped together in a fibrous covering to form a **lobe** of the gland. The lobule ducts are lined by a cubical epithelium, the smaller lobe ducts by a columnar epithelium, while the larger lobe ducts are lined by a stratified columnar epithelium.

During resting periods of the mammary gland, the smallest subdivisions are known as acini, but during functional activity they develop an alveolar form. About twenty large lobe ducts empty onto the surface of the nipple, these lobes being radially arranged and partly separated by connective-tissue septa. It is interesting to note as a variation from the general rule that each mamma is made up of about twenty separate compound duct glands.

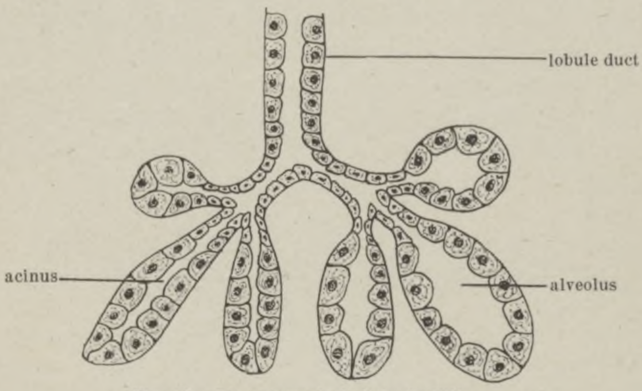

Fig. 19.—Diagrammatic **Lobule** (x 150).

Dissection.—The skin should be incised along the clavicle, the midline of the sternum and the lower margins of the ribs, and dissected off. The male mammary gland is a rudimentary organ, but if a female gland is available many of the points noted may be made out.

Fatty Layer and Fascia

The subcutaneous fatty layer has no special characteristics. It is supplied by segmentally arranged series of lateral and of anterior arteries, veins, and nerves. The area also contains, as would be expected, branches of the superficial venous system. The deep fascia has over the powerful muscles of the area rather more than average strength.

The fatty layer should be dissected off.

Muscles

The **pectoralis major** arises from the sternal third of the anterior border of the clavicle, from the front of the sternum and from the upper six costal cartilages (pectus = breast; major = greater). Its fibers converge and crossing in front of the arm-pit insert into the crest of the greater tuberosity, i. e., the lateral lip of the intertubercular groove of the humerus.

The **pectoralis minor** arises by fleshy strands from the third, fourth and fifth ribs under the pectoralis major and converging inserts into the tip of the coracoid process of the scapula.

The deep fascia should be cleared from off the muscles.

Fossa Axillaris

The axillary fossa or arm-pit is the cavity between the lateral surface of the chest and the medial surface of the arm. The pectoralis major muscle forms the anterior fold, while the latissimus dorsi with an associated teres major muscle forms the posterior fold. The skin over this region is thin and further characterized by a luxuriant growth of hair. The subcutaneous fatty layer is thin, but otherwise as elsewhere. The deep fascia is strong, is bound down by its connections, and is continuous with the deep fascia over the anterior and posterior folds.

Brachial Plexus

Five pairs of segmental nerves run through the axillary spaces; these are the fifth, sixth, seventh, and eighth cervical and the first thoracic. The five nerves and the five fingers are the permanent reminders of the fact that the upper extremity is made up of five vertebral segments. These nerves come out of their respective intervertebral foramina and approaching each other go through below the clavicle and above the first rib (foramen = window). The eight pairs of cervical segmental nerves are accounted for by one pair coming out under the skull and one pair under each of the cervical vertebræ. These nerves eventually take up a position deep down near the humerus on the medial side, as would be anticipated, for this is the most protected region. The nerves mutually interchange branches, which is the reason for the name brachial plexus (brachium = arm; plexus = weaving). In the middle of their passage through the axillary space the nerves become grouped about the axillary artery and are arranged in three cords, which on account of their relation to the artery are known as the **lateral, medial** and **posterior cords** (fasciculi). The lateral and medial are the anterior cords, which will later be demonstrated to gather all processes of supply to the front of the shoulder, arm, forearm and hand. The posterior cord carries the supply to the back of the shoulder, arm, forearm, and hand. The nerve trunks have little or no slack, so following a severe unexpected jerk of the arm, the nerve cords may be torn without serious injury to the bones or other parts.

Sympathetic Nerves

Axis cylinder processes of the sympathetic nervous system run into the upper extremity for the control of involuntary musculature, making the same segmental connections with the spinal cord as the peripheral nerves proper. All involuntary activities of the upper extremity are controlled by sympathetic processes, as for example sweating, contraction of the hair muscles and control of the blood supply. Messages also travel from the peripheral terminations of these sympathetic nerves to the spinal cord. Many of these sympathetic processes travel along with the connective-tissue sheath of the artery, while the bulk travel along in the brachial nerves proper en route to their terminations.

Arteries and Veins

Developmentally at an early stage of the embryo five segmental arteries and veins accompanied the brachial nerves. By the process as described under anastomosis, four of the primitive vessels disappear entirely, while the remaining vessel enlarges. The artery comes out from inside the chest and until it passes beyond the clavicle is known as the **subclavian**; through the axilla the artery is known as the **axillary**, while beyond the space it continues as the **brachial**. The corresponding vein receives corresponding names. As would be anticipated, the vein lies superficial to the artery, in fact in this instance just under the deep fascia. Two rather constant branches are given off from the artery to the anterior fold of the axilla, the one just beyond the clavicle being known as the thoracoacromial, while the branch near the lower border of the pectoralis major is known as the lateral thoracic. The branch arising towards the lower part of the space and running into the posterior fold is known as the subscapular. It is, as would be anticipated from an examination of the parts, very materially larger than the anterior axillary branches. A branch which comes off from the axillary artery near the lower border of the axillary space encircles the upper part of the humerus and is therefore known as the circumflex. The veins correspond to the arteries, while the lymphatic vessels follow the veins accurately.

Lymphatic Glands

The main group of lymphatic glands for the whole upper extremity and the neighboring trunk areas is to be found in the axillary fossa. Normal glands can not be distinguished in a dissecting room body on account of their small size, and fat-like consistency and color.

In acute infections the lymph glands become enlarged, soft and painful, and eventually may be overcome by the bacteria, breaking down into a pocket of pus. This pus would lie under the deep fascia, consequently the progress of escape can be hastened by incising the fascia layer. If the surgeon simply stabbed a knife through the skin, subcutaneous fatty layer and deep fascia, it is obvious that the brachial vessels and nerves and their branches might be seriously endangered. The external layers are commonly raised up by the pressure of the enclosed pus, but a sudden move might result in a serious catastrophe. Consequently the established surgical rule is to lay open the skin and subcutaneous fatty layer freely and then if necessary nick the deep fascia with a knife. Through this opening in the deep fascia a pair of blunt forceps may be introduced and opened without any danger. The tearing of the deep fascia, if the surgeon avoids putting extra pressure on the enclosed pus, does not cause any great amount of pain. A split piece of rubber tubing is commonly introduced through the deep fascia and sewed in place in order to make sure the fascia does not close before the drainage is completed. This is the generally accepted surgical rule for the opening of lymphatic gland abscesses in the neighborhood of their large veins and other important structures.

The enlarged glands secondary to cancer of the breast are characterized by their hardness and their tendency to remain separate and distinct.

Dissection.—The skin, the subcutaneous fatty layer and the deep fascia should be dissected off layer by layer from over the axillary fossa. In order to get a clean dissection of the area, it is then advisable to cut through the pectoralis major and minor muscles at a convenient midpoint and turn the divided parts back towards their origins and insertions. After noting that the axillary vein lies nearer the surface than the artery, the vein may be disregarded in the further cleaning up of the arteries and nerves. The lymphatic glands, unless diseased, will be hard to identify from the fat. When the fat and fascia is removed the points noted in the preceding discussion are ready to be made out.

Removal of Upper Extremity from Trunk

The only bony connection of the upper extremity to the trunk is through the clavicle, which acts as a radius rod holding the shoulder joint a fixed distance out from the sternum. It is especially exposed to fracture since either direct blows or falls on the lateral surface of the shoulder are liable to break it, usually in its middle third. In severe machinery accidents when the whole upper extremity is torn from the trunk, this slight clavicle is the only bony resistance to be overcome. As the muscles play a great part in the attachment of the upper extremity to the trunk, an unexpected jerk may find them off guard so that the strain falls on the clavicle and the brachial plexus nerve trunks. With or without a fracture of the clavicle the nerve trunks may be torn, very commonly inside of the vertebral column, which accident yields a complete permanent paralysis of the extremity.

The **serratus anterior** (O.T. magnus) muscle arises by slips from the first to the ninth rib along the front lateral chest wall and runs backward to its insertion in the costal surface of the scapula along the whole vertebral border (serratus = saw-shaped). The other muscles holding the upper extremity to the trunk have been previously considered, and after a review they may be cut across midway between their origins and insertions. The trapezius, rhomboids, levator scapulæ, pectoralis minor and the serratus anterior are the muscles holding the scapula to the trunk. In addition to these muscles the pectoralis major and the latissimus dorsi must be divided in order to complete the removal of the upper extremity from the trunk.

At this stage of the work it is advisable to remove only one upper extremity from the trunk. The removed extremity will allow a better demonstration of certain facts, whereas the attached extremity will yield a better understanding of the continuity of various structures. The clavicle of the upper extremity to be removed should be sawed across at its midpoint, and the axillary vessels and nerves sectioned just below the clavicle.

Rotator Muscles of Arm

Four muscles hold the head of the humerus against the glenoid cavity and attach to the tuberosities just below the anatomic neck of the humerus. The muscle arising from the greater part of the costal surface of the scapula is known as the **subscapularis.** It runs in front of the shoulder joint to its insertion into the lesser tuberosity, which lies medially to the intertubercular groove. The muscle arising on the dorsum of the scapula above the ridge is the **supraspinatus.** It runs over the top of the shoulder joint and attaches to the upper facet of the greater tuberosity. The muscle arising on the dorsum of the scapula below the ridge or spine is the **infraspinatus.** It converges and runs across the back part of the shoulder joint to its attachment to the second facet of the greater tuberosity. Arising somewhat lower down along the axillary border of the scapula is a smaller muscle closely associated with the infraspinatus, which is known as the **teres minor** (teres = round). The teres minor inserts into the lowest facet of the greater tuberosity. The origins and insertions of these muscles explain their respective internal and external rotary powers, the subscapularis being an internal rotator, whereas the infraspinatus and teres minor are external rotators. If they all act powerfully at the same time they tend to hold the head of the humerus firmly in the glenoid cavity.

These muscles should be cleared of their fascia coverings and traced out to their origins and insertions.

Adduction of Arm

Adduction refers ordinarily to the midline of the body (ad = towards; duco = lead). The pectoralis major muscle converges on a tendon, turning on itself so as to yield a rounded lower border. It forms the anterior fold of the axillary fossa and inserts into the crest of the greater tuberosity, i. e., the lateral lip of the intertubercular groove. The latissimus dorsi tendon passes the inferior angle of the scapula, turns around the teres major muscle in the posterior fold of the axilla, and inserts into the bottom of the intertubercular groove. The **teres major** muscle is closely associated with the latissimus dorsi. It arises from the axillary border of the scapula near the inferior angle and inserts into the crest of the lesser tuberosity, i. e., the medial lip of the intertubercular groove. These muscles would obviously draw the arm in towards the midline of the body, and so justify their classification as adductors. Inasmuch as the intertubercular groove is on the anterior surface of the humerus, they would also produce a limited internal rotation.

Abduction of Arm

Abduction (ab = away from) is produced mainly by the action of the **deltoid muscle** (delta = triangular Greek letter). Arising from the anterior surface of the acromial third of the clavicle, the lateral margin of the acromial process and the inferior margin of the spine of the scapula, this muscle converges onto a tendon, which inserts into the middle of the lateral surface of the shaft of the humerus. This muscle has the power of raising the arm only to a right-angle with the body, whereas the carrying of the arm to full elevation is accomplished through rotation of the scapula. The **supraspinatus** muscle, described as a matter of convenience in connection with the rotators, is an abductor.

The skin should be dissected off to the middle of the arm, and the abductor and adductor muscles cleared of their fascias and traced out.

Flexion and Extension of Arm

The word flexion means bending, while the word extension is applied to the opposing action or straightening. The muscle which has the power of drawing the arm forward as its essential function is known as the **coracobrachialis.** This small muscle arises in common with the short head of the biceps from the tip of the coracoid process and inserts near the middle of the humerus on its medial surface. The biceps muscle is also a flexor of the arm at the shoulder, this action being only a subsidiary power of this complicated muscle (biceps = two-headed).

The **long head of the triceps** or three-headed muscle arises from just under the glenoid cavity of the scapula and joins the other heads of this muscle in the lower posterior part of the arm. This long head of the triceps is the main extensor muscle of the arm at the shoulder.

The coracobrachialis and the long head of the triceps muscle should be cleared of their fascias and traced out. The consideration of the muscle groups controlling the shoulder, now completed, gives the simple components of the very wide range of motion. To summarize, these movements are flexion and extension, abduction and adduction, and internal and external rotation.

The Arm (Brachium)

Most of the humerus is heavily covered by muscles, but the lateral and medial epicondyles at the elbow region are readily palpable as bony prominences. The skin over the lateral surface of the arm being more exposed to injury, is tougher than over the medial surface.

The skin should be dissected off the remainder of the arm and the upper half of the forearm.

Superficial Venous System

In the superficial fatty layer are to be found the routine cutaneous arteries, veins and nerves, and the superficial venous system. This part of the superficial venous system deserves more careful consideration than usual, as it has been historically and is today the site of election for blood-letting. It lies in the subcutaneous fatty layer, but anastomoses with and eventually joins the deep venous system. The **median** vein courses up to the middle of the front of the forearm and divides just below the elbow into a **mediancephalic** and a **medianbasilic.** A profunda branch runs from about the junction of these three vessels through the deep fascia to join the deep venous system. The median cephalic is joined by a radial vein, while the median basilic is joined usually by two ulnar branches (the radius is the lateral bone of the forearm, the ulna the medial). In the description of the veins after they have received these branches the term median is dropped. The **cephalic** vein runs upward along the posterior lateral border of the biceps muscle, follows along between the pectoralis major and deltoid muscles, and eventually dips down to join the subclavian vein just below the clavicle (cephalic = towards head). The **basilic** vein follows along the posterior medial border of the biceps and dips down to join the brachial vein just below the axillary space. The name basilic is said to mean base, and was due to an historical misconception and exaggeration of its importance. The median basilic being the larger is commonly chosen for blood-letting, but it should be noted that it crosses directly over the main vessels, separated only by a layer of deep fascia.

The superficial venous system should be dissected out, and then the subcutaneous fatty layer should be removed.

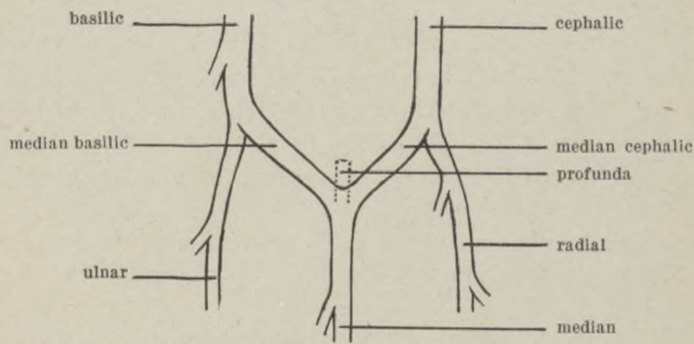

Fig. 20.—Diagram of **Superficial Veins**, from in front, left arm.

Deep Fascia

The deep fascia should be noted to be stronger on the lateral side of the arm, and much stronger in the region of the elbow where the big muscle bellies join their tendons. The fascia sends in intermuscular septa between the muscles and extra strong partitions, the intergroupal septa, down to the bone between the front and back compartments of the arms. The front compartment contains the flexor muscle group, while the back contains the extensor group. In the lower half of the arm these intergroupal septa help raise up the medial and lateral margins of the humerus.

Anterior or Flexor Compartment

The short tendon of the **biceps** brachii muscle arises from the tip of the coracoid process, while the long tendon arises from the top of the glenoid cavity of the scapula. The long tendon traverses the shoulder joint, then emerges and helps to form the intertubercular groove on the anterior surface of the humerus. The intertubercular groove was known in the old terminology as the bicipital. These tendons swell out into the popularly known bellies of this muscle, which converge onto another tendon of insertion, running to the radius just below the elbow joint.

In the early developmental stage of embryonic life the muscle

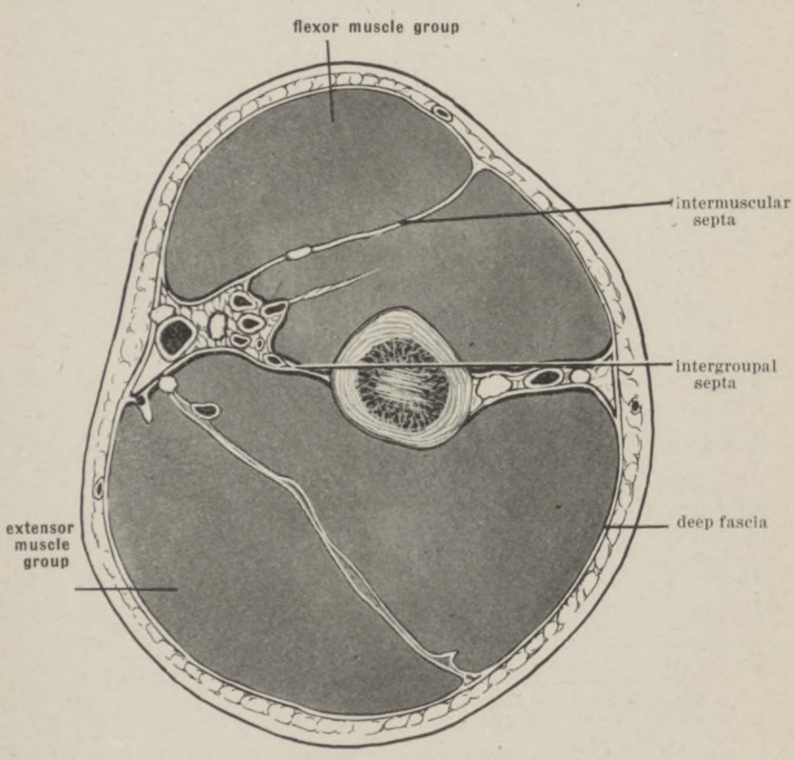

Fig. 21.—Fascial compartments at middle of Arm.

arrangement is much simpler than in so complicated a muscle as the biceps. When muscles are first developed they run from a region past a joint into the next bone, as for example from the shoulder to the arm, or from the arm to the forearm. By fusion of two separate embryonic muscles, such complicated muscles as the biceps are developed. The biceps has the double power of flexing the arm at the shoulder and the forearm at the elbow.

The **brachialis** (O.T. brachialis anterior) muscle arises from the front lower half of the humerus, lies deep to the biceps, and inserts into the ulna just below the elbow. The biceps and brachialis muscles act on a short lever speed principle and are mainly flexors of the forearm, although the biceps as will be noted later has still another important action.

The deep fascia should be split in the midline and dissected back on each side to the intergroupal septa in order to clear these muscles.

Posterior or Extensor Compartment

The **triceps** brachii muscle arises from a lateral or upper head and a medial or lower head from the back of the humerus. Between these two heads lies the radial nerve, accompanied by an artery and vein. The old terminology for the radial nerve was musculospiral. The long head of the triceps muscle arises from the scapula just below the glenoid cavity of the scapula, as noted in connection with extension at the shoulder. All three heads join onto a common tendon, which attaches to the elbow point or **olecranon** of the ulna. Fracture of the humerus in its middle third may result in catching the radial nerve between its rough ends with resultant complete destruction of nerve function below the point. This accident commonly calls for surgical relief.

The **anconeus** muscle arises from the lateral epicondyle of the humerus and inserts along the posterior margin of the ulna throughout its upper third. It therefore acts as an extensor of the forearm and is an accessory to the triceps. Although the anconeus lies regionally in the forearm, on account of similar function it is fittingly considered with the triceps.

These muscles should be cleared of their fascias and traced out.

Vessels

The **brachial** artery and vein run down well protected under the medial border of the biceps muscle to a midline position in front of the elbow. As the muscle belly gives way to tendon, the skin approaches nearer to the artery, which during life can be felt pulsating in front of the elbow, just medially to the biceps tendon.

Instead of giving off a great number of small branches the general tendency of larger arteries is to give off a main branch, which in turn gives off the smaller branches. The main branch from the brachial comes off in the upper part of the arm, and on account of its relations is known as the **profunda**, or deep. This profunda brachialis stem gives off numerous branches to the muscles, and also branches accompanying the main nerves. Just above the elbow the brachial artery gives off superior articular branches, which anastomose with the inferior articular branches below the joint. This arrangement, although names may vary in different areas, is practically universal at all the really freely movable joints. The deep venous system is made up of paired veins (venæ comitantes), but otherwise corresponds to the arteries.

The vessels should be cleared and traced out.

Brachial Plexus

The brachial plexus is formed by the union of the fifth, sixth, seventh, and eighth cervical and first thoracic segmental nerves. These become known in the mid-axilla as the lateral, medial, and posterior cords on account of their relation to the axillary artery (cord = B.N. A. fasciculus). The lateral cord divides into the **musculocutaneous** branch and the lateral head of the median nerve. The musculocutaneous supplies the biceps and brachialis muscles, and continues as a small cutaneous branch down the lateral anterior surface of the forearm. The medial head of the median nerve is supplied by the medial cord. The large **median** nerve then continues down in company with the brachial vessels, and eventually will be noted to take a midline position in the forearm. The continuation of the medial cord is known as the **ulnar,** which runs contrary to what would be expected in back of the medial epicondyle of the humerus in its course into the forearm. The ulnar nerve can be easily palpated just posterior to the median epicondyle, and it is the impinging of this nerve against the bone which yields the name humerus or funny bone. The posterior cord sends off a large circumflex branch to the shoulder region, and then continues through the posterior compartment of the arm as the **radial.** The radial nerve forms a groove between the lateral and medial heads of the triceps muscle and passes contrary to what would be expected in front of the lateral epicondyle of the humerus. It supplies both the muscular and cutaneous branches to the posterior compartment of the arm, and eventually of the corresponding compartments of the forearm and hand. It peculiarly does not supply sensation to the back of the fingers.

The nerves should be traced through the arm.

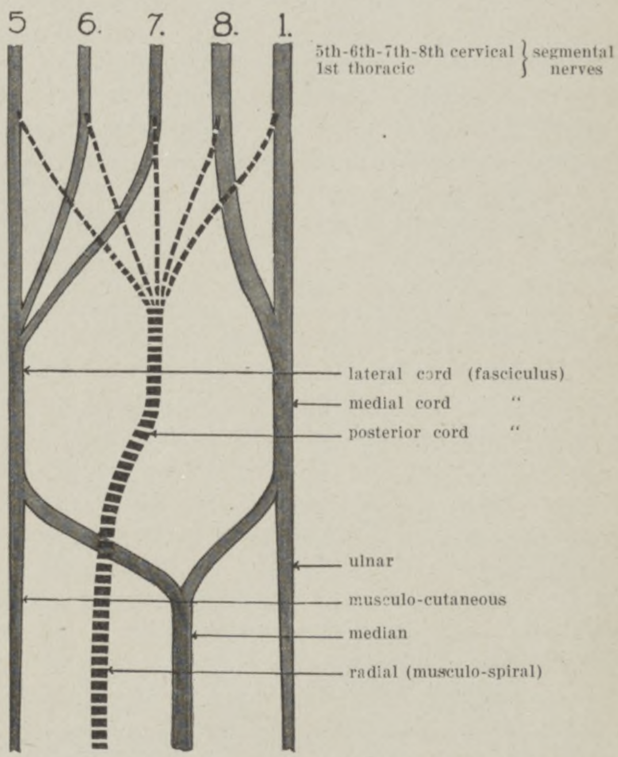

Fig. 22.—Diagram of **Brachial Plexus.** (Dotted lines are parts in posterior compartments).

Shoulder Joint (Articulatio Humeri)

The shoulder joint is a diarthrodial articulation of the ball and socket type. It is the joint between the head of the humerus and the glenoid cavity of the scapula. It possesses a very wide range of motion, which may be classified as abduction and adduction, flexion and extension, and internal and external rotation. After resection of all the muscles and an incision into the capsule so as to obviate suction, the great strength of the capsular ligament may be tested by trying to pull the humerus from the scapula. The capsular ligament runs from around the glenoid cavity to the anatomic neck of the humerus, and may be noted to be composed of fibers running mainly in parallel bundles. The capsular ligament is then to be cut across midway between the humerus and scapula, when the **long tendon of the biceps** running to its insertion at the upper part of the glenoid cavity will come into view. This is a characteristic, unique feature of this joint. This tendon must be cut across in order to separate the bones. The cartilage covering of the bones is to be noted, and the very smooth synovially lubricated interior of the joint. Above the joint the overprojecting acromion and coracoid processes are joined by a strong ligament, logically named the **coracoacromial ligament.** This arch is an important element in increasing the size of the socket. Between the upper surface of the capsular ligament and the under surface of this coracoacromial arch lies a **bursa**, an endothelial sac lubricated by synovial glands.

General Rule of Nerve Supply

The same segmental nerves that supply the muscles controlling a joint, send cutaneous branches to the skin of the area, and also sensory branches into the interior. This gives an anatomic basis to two well-established clinical facts; the influence of surface applications on joint pains and the muscular protective rigidity of a joint in case of inflammation in its interior. The arteries, veins, and lymphatics are from the neighboring smaller vessels.

Dislocation

The coracoacromial arch prevents the head of the humerus from jumping out of the socket in any direction except inferiorly. With the arm fully abducted a fall on the palm of the hand may and not infrequently does, cause the head of the humerus to tear its way through the inferior portion of the capsular ligament. After it has escaped from the capsule, the head may take any one of a number of secondary positions. The separation of opposing bones is known as dislocation or luxation. The importance of muscular resistance in holding the bones together has been emphasized, therefore if the muscles are caught off guard the probability of dislocation is greater. In order to reduce a dislocation the rigidity of the muscles is often advisedly lessened by an anesthetic before reduction is attempted.

Acromioclavicular Joint

The acromioclavicular joint allows only a limited degree of gliding motion in all directions. The interior of this joint cavity differs from the usual type in the presence of a complete partition, an interarticular disc of fibrocartilage. The clavicle is bound down firmly to the root of the coracoid process by a strong ligament, named logically the **coracoclavicular ligament.** Fractures of the clavicle usually occur medially to this connection with the coracoid process.

FOREARM AND HAND (ANTIBRACHIUM ET MANUS)

The forearm, hand and fingers are considered together for the reason that several muscles from the forearm continue down to the fingers. As usual in taking up the consideration of a region, the bones will first be described, with special stress laid on the more important landmarks.

Ulna

The ulna is the medial bone of the forearm. It is a long bone with usual type of development, that is, a diaphysis and two epiphyses, or in the adult a body, or shaft, and two extremities. The ulna has the characteristic elbow point or **olecranon** process, which serves to grasp the lower end of the humerus. The front portion of this grasping curve is the **coronoid process,** whereas the curved surface between these two processes is known as the semilunar notch (luna = moon). The lower extremity has a small rounded **head,** with a projection from its medial surface known as the **styloid process** (stylus = quill pen). The dorsal margin of the ulna is not covered by muscles and consequently is a most important landmark of the forearm. Running between the opposing surfaces of the radius and ulna is a woven white fibrous layer, the **interosseus membrane.** This layer raises up a sharp ridge on the lateral surface of the ulna and also on the medial surface of the radius.

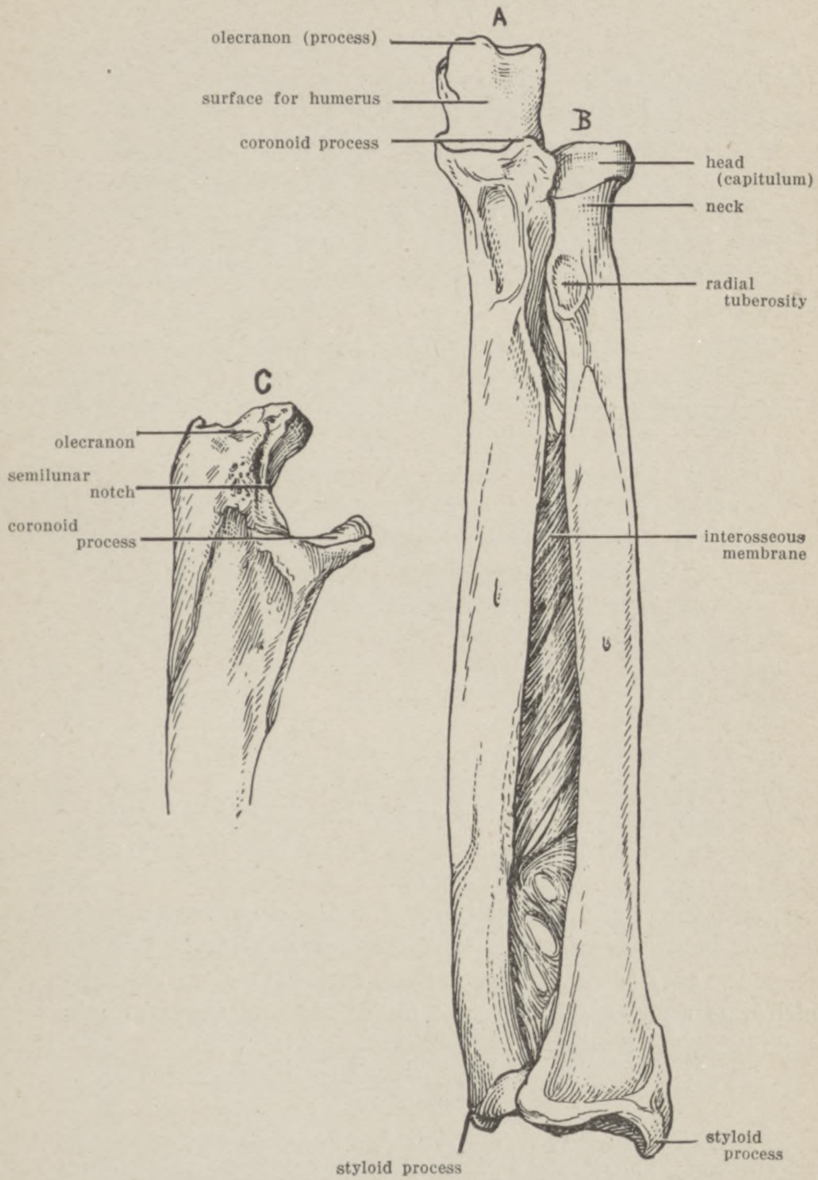

Fig. 23.—Left **Ulna** (A) and **Radius** (B), anterior surface. (C) medial view of upper extremity of ulna.

Radius

The radius, the bone that turns or radiates about the ulna, is a typical long bone. With the thumb side of the hand held outward, the radius parallels the ulna, whereas with the thumb turned inwards it crosses over the ulna. External rotation of the forearm, that is with the thumb held out, is known as the supine position, whereas, internal rotation of the forearm, that is with the thumb held in, is the prone position. At least two bones are required in the forearm in order to allow for these changes in position. The radius has a small disc-shaped **head,** the upper surface of which is slightly concaved to fit over the rounded lower surface of the humerus. The constricted **neck** is surrounded by a firm encircling ligament, which holds the radius steady during rotation. The **radial tuberosity** just below the neck and on the medial side is raised up by the attachment of the biceps muscle. At its lower extremity the radius widens out to meet the bones of the wrist, while projecting from its lateral surface is a **styloid process.** The head of the radius can be felt about one-half inch below the lateral epicondyle of the humerus, and its position verified by rotating the forearm. Due to the muscle bellies giving way to tendon the lower third of the radius is readily palpable.

Carpals

The wrist has a number of small very irregular bones, two rows of four each, known as the carpal bones. Their dorsal surfaces are readily palpable, while on the ventral surface a lateral and a medial ridge is not covered by muscle. A logical identification system for these bones would be to number them from the thumb side inwards, one, two, three, and four of the first and second carpal rows. Their names, hard to remember and of minor importance, in the same sequence are: os naviculare manus, os lunatum, os triquetrum, os pisiforme and os multangulum majus, os multangulum minus, os capitatum, os hamatum.

Metacarpals

The hand has as its framework five metacarpal bones, which are readily palpable from the dorsal surface. The rounded heads of the metacarpals fit into shallow sockets at the bases of the first phalanges.

Phalanges

The phalanges are three in number to each finger except the thumb, which has only two. Their dorsal and lateral surfaces are especially superficial. The accepted system of numbering the meta-

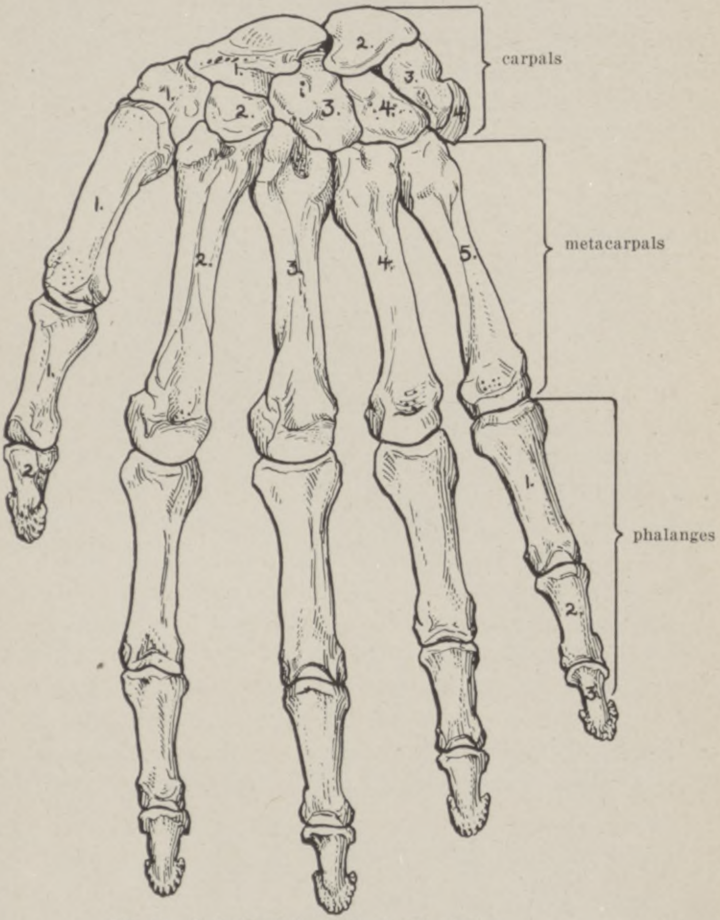

Fig. 24.—Left **Hand** (manus), dorsal surface.

carpal and phalangeal bones is noted on the diagram. The words proximal and distal are widely used in the consideration of the forearm and hand, proximal meaning nearer to the trunk, distal further away.

The Skin

The skin has relatively greater thickness over the radial parts of the forearm in conformity with its greater exposure. On the palmar surface of the hand and fingers the skin is very thick, the epidermis becoming extraordinarily thick in the calloused hand of a laborer. The line creases in the palm and across the fingers are thin areas of the skin to allow for the closing of the hand, and are more noticeable in the hands of strong people. It is to be specially noted that the creases do not lie over the metacarpophalangeal series of joints. The finger-nails are special structures developed from the epidermis. Neither hair nor sebaceous glands are present in the palm.

The skin should next be dissected off and even though extra difficult, care should be exercised to stick as closely to the under surface as possible.

Subcutaneous Fatty Layer

The subcutaneous fatty layer contains the cutaneous arteries, veins and nerves, and branches of the superficial venous system. The cutaneous nerves on the back of the forearm and hand are generally speaking derived from the posterior cord, whereas all in front are from branches of the lateral and medial cords. The palmar surfaces of the fingers and thumb over the distal phalanges have an extraordinarily liberal nerve supply, and here the sense of touch is highly developed. The large size of the cutaneous nerves in comparison with the small area for supply is especially to be noted. In the central compartment of the palm and over the fingers the subcutaneous fatty layer is characterized by the great amount of the fibrous tissue element, which makes this layer extremely tough and resistant.

The fatty layer should be dissected off.

Deep Fascia

The deep fascia surrounds and encloses all the muscles of the forearm and hand in a firm sheath. Over the central compartment of the palm the deep fascia is very strong and in the case of a manual laborer very materially stronger. This deep fascia is reinforced by the aponeurosis of the **palmaris longus muscle.** This combination deep fascia and aponeurosis serves as a protection to the deeper structures. The portion of the deep fascia across the back of the wrist is extra heavy and receives the special name of **dorsal carpal ligament.** The **transverse carpal ligament** in front of the wrist is even stronger, due to the more powerful group of muscle tendons it has to hold down. The old terminology was anterior and posterior annular or ring ligaments. This transverse carpal ligament raises up a ridge on the lateral and medial sides of the front surfaces of the carpal bones, which projections are readily palpable. Across the front surfaces of the fingers the deep fascia is strengthened and

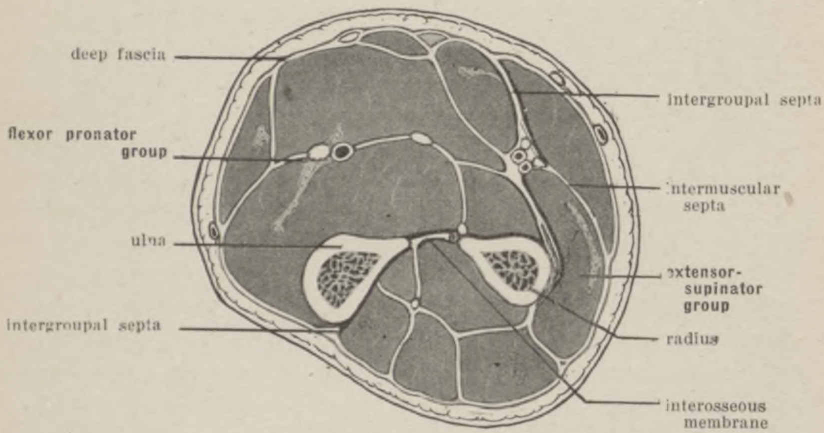

Fig. 25.—Fascial compartments at middle of Forearm.

attached to the junction of the front and collateral surfaces of the phalanges in order to hold down the tendons. These **flexor tendon sheaths** (ligamenta vaginalia) possess synovially lubricated interiors.

Muscles

The flexor group of muscles of the forearm has the power of bending the fingers on the hand and the hand on the forearm. The pronator group of muscles has the power of turning the radius over the ulna, that is internal rotation. The flexor muscles of the fingers are as popularly known much more powerful than the opposing extensors. The flexor-pronator group arises in the main from a common tendon on the medial epicondyle of the humerus, as may be noted by contracting the muscles. These muscles should also be noted to arise from the deep fascia and intermuscular septa of the upper part of the forearm, thus obtaining a secondary indirect attachment to the bones. The extensor-supinator group arises in the main from a common tendon on the lateral epicondyle of the humerus. These two muscle groups are separated by the subcutaneous dorsal margin of the ulna, whereas in front the two groups are not well marked off.

Flexors and Pronators

The **pronator teres** runs from the common tendon and an accessory ulnar head deeply across the forearm to the middle of the radius, wrapping itself half way around the bone. It is to be specially noted that as a matter of logic all pronators and supinators must insert into and act on the radius.

The **flexor carpi radialis** runs superficially across the transverse carpal ligament to its spread-out insertion on the carpal and base of the metacarpal bones of the radial side. Its tendon is readily seen above the wrist.

The **palmaris longus** runs over the transverse carpal ligament about its middle to the deep fascia of the palm.

The **flexor carpi ulnaris,** arising from the common tendon and also from the ulna, runs over the transverse carpal ligament to its insertion in the carpal and base of the metacarpal bones on the ulnar side.

The **flexor digitorum sublimis** (superficialis) arises from the common origin and an accessory radial head, and divides up into four tendons, which run under the transverse carpal ligament. These tendons separate in the palm and enter their respective flexor sheaths. Each tendon in this synovial sheath divides into two parts, which insert on the sides of the second phalanx.

The deep group of muscles does not arise from the common tendon.

The **flexor digitorum profundus** arises underneath the superficial flexor from the interosseous membrane and the ulna, and follows the same division and course into the flexor sheaths. Each tendon then runs through the divided superficial tendon to its attachment at the base of the third phalanx. The four **lumbricle** muscles, running from these tendons in the palm to the deep fascia on the back of the fingers, act by taking up slack and straightening out the line of pull (lumbricle = earthworm).

The **flexor pollicis longus** arises from the radius and the interosseous membrane, runs under the transverse carpal ligament to the flexor sheath of the thumb, and inserts into the base of the terminal phalanx (pollex = thumb).

The **pronator quadratus** is a thin square sheet, arising from the lower part of the ulna and inserting into the lower part of the radius.

Short Muscles of Hand

The intrinsic muscles of the hand arise from the carpal or metacarpal bones and insert into the base of the first phalanges. An exception is the small opponens muscle of the thumb and of the little finger, which arise from a carpal bone, and lie next to and insert into the metacarpal bone. The comparative anatomy of the short muscles of the hand is complicated in its detail because some of the muscles found well developed in the lower animals have become greatly modified or have disappeared from the human hand. Although the muscles belong to various comparative groups, muscles which functionate as abductors, adductors and short flexors exist for all five digits. The terms abduction and adduction are used with reference to the midline of the hand. The metacarpal bone of the thumb has a free range of motion, contrasting sharply with the condition of the other metacarpals. The proximal end of the medial four metacarpal bones have only a slight range of motion, which, however, is magnified in amount at the distal end of these bones.

The relatively large muscles making up the muscular mass over the thumb metacarpal are named from the radial side medially, the abductor pollicis brevis, the flexor pollicis brevis, the adductor pollicis and on a deep plane the opponens pollicis. Covering the ulnar side of the fifth metacarpal lies the relatively large abductor digiti quinti, along the lateral side of which lies the flexor digiti quinti brevis, the opponens digiti quinti lying deep between these two muscles. The muscles lying between the metacarpal bones, known as the interossei, are divided into a volar, or palmar, and a dorsal group. The volar group of interossei muscles are three in number and are arranged so as to act as adductors of the first phalanges. The dorsal group of interossei muscles are four in number and are arranged so as to act as abductors of the first phalanges. Both of these groups of interossei muscles act also as functionally unimportant flexors of the first phalanges. Comparative anatomy and the nerve supply from the anterior cords in the human hand both demonstrate that the dorsal group of interossei muscles belong to the palmar musculature and only secondarily take a semidorsal position between the metacarpal bones.

Blood Supply

The brachial artery and vein dip down into the forearm between the flexorpronator and the extensorsupinator muscle groups. The **radial** branch continues down between these two muscle groups and becomes superficial near the wrist, which is the routine point of selection for palpation of the pulse wave. The **ulnar** branch runs deeply under the pronatorflexor group of muscles, but is palpable above the wrist. The continuation of the brachial artery is known as the **common interosseous**, which almost immediately breaks up into ventral and dorsal interosseous divisions, so called on account of their relation to the interosseous membrane. Recurrent branches from all these vessels are given off for the elbow region, large muscular branches at intervals, and eventually smaller anastomosing branches above the wrist.

The ulnar artery proceeds through a compartment of the transverse carpal ligament into the hand, remaining beneath the deep fascia. The radial artery turns laterally at the carpal bones, goes around the metacarpal bone of the thumb and then turns back into the deep part of the palm. The connecting vessel between the ulnar and radial arteries lying superficial to the flexor tendons is known as the **superficial volar** or palmar **arch,** which lies on a level with the base of the outstretched thumb. The branches of the superficial volar arch run forward between the metacarpal bones to the web of the fingers, sending digital branches along both protected sides of the fingers. The **deep volar** or palmar **arch** is materially smaller, lies up much nearer to the carpal bones, and besides supplying the area sends branches between the metacarpals to the back of the hand. The superficial volar arch is normally made up chiefly by the ulnar, the deep volar arch chiefly by the radial. These volar arches are both beneath the deep fascia as is the rule for larger arteries.

and receive the adjective *superficial* and *deep* solely on account of their relation to the flexor tendons.

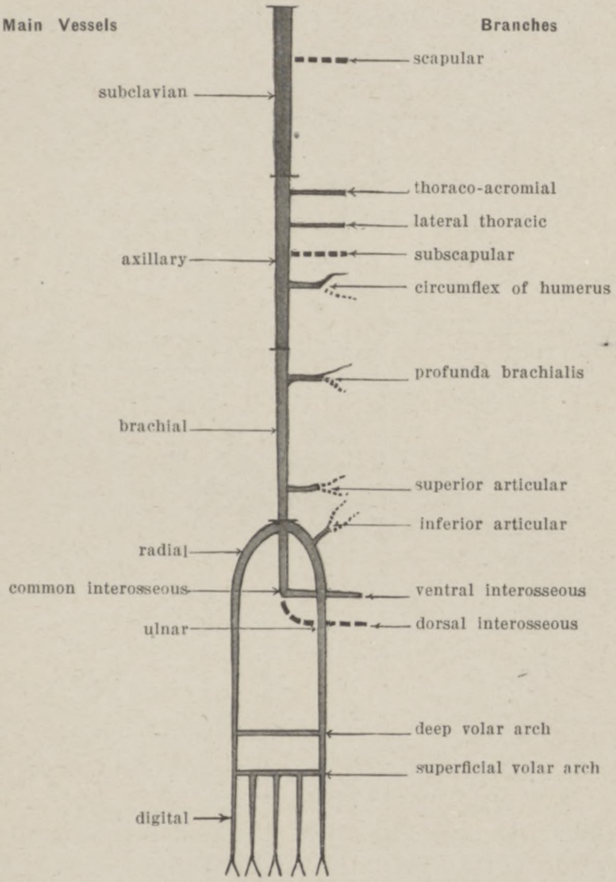

Fig. 26.—Diagram of Arteries of upper extremity. (Dotted lines are parts in posterior compartments.)

Nerves

The **ulnar** nerve enters the foramen between the medial epicondyle and the olecranon, runs deep through the muscle group supplying the flexor carpi ulnaris, and then follows the ulnar artery in its further course. In general it tends to supply the medial half of the hand and fingers. The large size of the branches for the palmar surface of the distal phalanges of the medial two and one-half fingers should be noted. The **median** nerve follows the brachial artery and

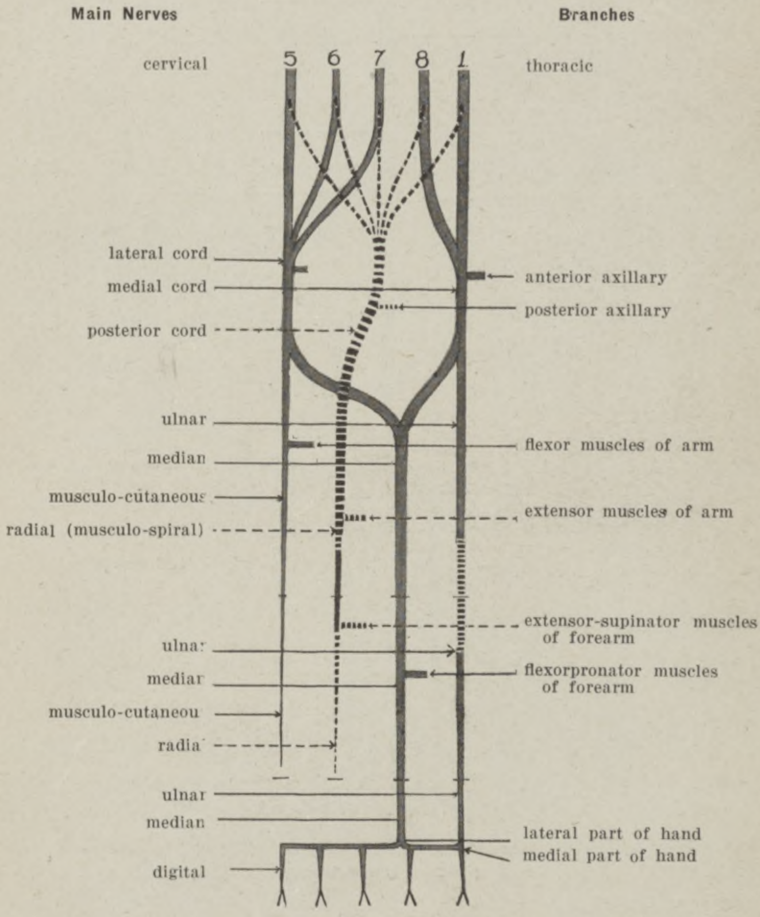

Fig 27.—Diagram of Nerves of upper extremity. (Dotted lines are parts in posterior compartments.)

vein into the mid-upper part of the forearm, sends off branches supplying the flexorpronator muscle group, and eventually goes through under the transverse carpal ligament into the palm. In general it supplies the lateral side of the hand, and sends large cutaneous branches to the finger tips of the thumb, index, and lateral half of the middle finger.

Dissection.—The deep fascia should be opened up over the flexor-pronator muscle group and should be dissected off from the palm of the hand. After the various structures noted in the preceding discussion have been traced out, the flexor tendon sheaths and eventually the transverse carpal ligament may be opened up.

Practical

Pus under the tough fascias of the palm would obviously have an extremely difficult task in working to the surface. The great associated swelling of the loose tissues of the back of the hand often leads the inexperienced to an erroneous diagnosis and treatment. Pus in the palm on account of the tough layers does not produce much swelling, but may be recognized by local tenderness on pressure. It should be evacuated early in order to stop the pain and to minimize the danger of spreading. The incision should be in a line over the metacarpal bone and should not commence nearer the wrist than the base of the outstretched thumb, on account of the danger to the superficial volar arch. The fairly common bone infections of the distal phalanges are popularly known as bone felon or whitlow, and are extremely painful so long as the pus is enclosed in the bone. An incision into the flexor tendon sheaths may cause the infection to spread into the palm, or in the case of the thumb or little finger even to the synovial sheath of the wrist region.

Extensors and Supinators

The extensor and supinator muscle group arises in the main from a common tendon from the lateral epicondyle of the humerus, although minor secondary origins are present. This group is marked off on the back of the forearm by the dorsal margin of the ulna, whereas on the front surface the dividing line is not well marked. The extensors of the fingers are much weaker than the flexors, but the extensors of the wrist are approximately equal to the flexors in strength.

The biceps muscle wraps around the medial side of the radius, as a result of which it is not only a flexor, but also a strong supinator of the forearm. The supinator group is on this account materially stronger than the pronator group. The threads on screws are commonly set so as to utilize this power in driving the screw inward.

The **brachioradialis** (O.T. supinator longus) arises from the lateral margin of the humerus and runs down to a tendon attachment to the lateral surface of the lower part of the radius. This muscle is a flexor of the forearm at the elbow and also to a minor degree a supinator. Between the brachioradialis and the flexor carpi radialis, an intergroupal fibrous septa runs from the deep fascia down to the bone.

The **extensor carpi radialis** arises from the common tendon and inserts by two separate tendons into the carpal and base of the metacarpal bones on the radial side. This muscle, in fact all these muscles which pass the wrist, run through separate compartments in the dorsal carpal ligaments.

The **extensor digitorum communis** arises from the common tendon and spreads out over the back of the hand into four tendons for the respective fingers. These tendons attach partly to the sides of the second phalanges and terminate at their attachment to the base of the distal phalanges.

The **extensor carpi ulnaris** arises from the common tendon and the dorsal margin of the ulna throughout and inserts into the base of the fifth metacarpal.

The thumb has two special extensors, which arise in the lower back part of the forearm, and insert into the bases of the first and second phalanges. The muscle which inserts into the base of the thumb metacarpal is known as the abductor pollicis longus. The index finger and little finger have extra separate extensor muscles.

The **supinator** (brevis) arises by a short tendon from the upper lateral surface of the ulna and wraps around the lateral side of the upper half of the radius, more markedly so when the forearm is pronated. It lies next to the bone, hence deeply under the other muscles.

Vessels and Nerves

The posterior cord continues as the radial nerve through the back of the arm, runs contrary to what would be expected in front of the lateral epicondyle, and terminates in the extensorsupinator group of muscles. This nerve also supplies the skin over the back of the forearm and hand. Theoretically it should also supply the skin over the back of the fingers, but as a matter of fact the supply for this area comes mainly via the anterior cords of the brachial plexus. Branches from the dorsal interosseous arteries and veins furnish the main blood supply.

Dissection.—The extensor-supinator group of muscles should be cleared and traced out. The vessels and nerves should also be followed out.

Radio-Ulnar Joints

Near the proximal extremity a strong collar arises from the lateral surface of the ulna, and encircling the neck of the radius attaches again to the ulna. This is known as the **annular ligament** (O. T. orbicular) of the radius, which, while holding the radius in position, allows free rotation. The depression on the lateral surface of the ulna made by the head of the radius is known as the radial notch. At the distal end a powerful ligament arises from a point at the base of the styloid process of the ulna and, widening out, attaches to the lowest ulnar surface of the radius. This ligament is the **discus articularis,** which, while allowing free rotation, prevents the radius from spreading away from the ulna. The discus articularis was formerly well named the triangular fibrocartilage.

Elbow Joint (Articulatio Cubiti)

The elbow joint is a diarthrodial articulation of the hinge type, being the junction of the humerus with the radius and ulna. It is to be especially noted that the forearm in full extension does not continue straight down in line with the axis of the arm, but distinctly deviates laterally, forming the so-called carrying angle. When the joint is fully extended the anterior part of the capsular ligament is tense, whereas in full flexion the posterior portion becomes taut. As no muscles directly resist side-to-side strain, the lateral and medial parts of the capsular ligament are especially thickened, and are known as the **radial and ulnar collateral ligaments.** The capsular ligament should be cut around about its midpoint. The semilunar notch of the ulna fits over the rounded ulnar surface of the humerus, and on close inspection a tongue-like projection of the ulna will be noted to fit into a corresponding groove of the humerus. This is a typical arrangement for hinge joints. The disc-shaped head of the radius shows a depression, which fits over the radial ball-shaped surface of the humerus. The olecranon process, the coronoid process, and the radial head all fit into pits in the lower part of the humerus, which arrangement allows for free flexion and extension at the elbow. The interior of the joint is otherwise not characteristic, but it should be noted that the proximal radioulnar joint is continuous with the elbow joint proper.

Backward dislocation of the ulna on the humerus occurs quite frequently in childhood. It rarely occurs in adult life, and then ordinarily in association with fractures of the coronoid process. A bursa is present in the fatty layer over the olecranon process, with the obvious purpose of allowing the skin to slide and consequently reducing the liability to injury.

The elbow joint should be dissected.

The Wrist

What is popularly known as the wrist is composed in reality of three joints: The **radiocarpal,** the **intercarpal,** and the **carpometacarpal.** After removal of the muscles the strong anterior and posterior portions of the capsular ligament are exposed to view. The cord-like **radial and ulnar collateral ligaments** of the carpus, being unsupported by muscles, are specially strong, and their attachments to the lower ends of the radius and ulna raise up the styloid processes. The interior of the radiocarpal joint has a separate synovial membrane, while the intercarpal and carpometacarpal synovial cavities are generally distinct, sometimes, however, continuous. Strong interosseous ligaments run between the different carpal bones and are a large factor in the strength of the wrist. The motion at each joint is small, but the full range is brought out by the summation of the radiocarpal, intercarpal, and carpometacarpal movements. The lower end of the radius is widened out to meet all the first row of carpal bones, as must be so in order that the hand follow the movements of the radius. The articular disc, which connects the distal extremity of the ulna to the radius, shuts out the head of the ulna from meeting the carpal bones.

A fall on the outstretched palm, breaking through the lower part of the radius with backward displacement of the hand, is known as Colles' fracture. This injury is almost always accompanied by a rupture of the ulnar collateral ligament or a fracture of the styloid process of the ulna. Chronic inflammation in the wrist joint may produce an increase in joint secretion, bulge out the capsular ligament, and cause rounded fixed swellings on the back of the wrist.

The wrist joint should be dissected.

Phalangeal Joints

The metacarpal-phalangeal joints have a rounded metacarpal ball and shallow phalangeal socket, allowing limited collateral motion but free flexion and extension. The two interphalangeal series of joints show a slight tongue and groove arrangement, as in all hinge joints. The extensor digitorum tendons become intimately blended with the posterior portion of the capsule of these joints.

These joints should be dissected.

Bone Section

One or more of the long bones of the upper extremity should be sawed longitudinally. This dissection will allow an examination of the interior of the body or shaft and the two extremities, or, if the body is of youthful age, of the diaphysis and the two epiphyses. The varying resistance to the cutting action of the saw will in itself demonstrate the inequality of the strength of the bone. A cursory examination of the cut halves will demonstrate that there is no ratio between the outward size and the real strength. Clinically, generally speaking, there is no greater liability of fracture at the large weak end portions than at the solid smaller shaft. The bones are so arranged architecturally as to yield throughout the ordinarily required strength plus a factor of safety, while at the same time minimizing weight.

The tubular shaft is made up practically of solid bone, known as the **compact** substance. The end portions have a narrow, compact inner and outer shell, between which lies the porous **spongy** substance. The spongy portions of the bone are filled with red bone marrow, while the large **medullary cavity** is filled by the fatty yellow bone marrow throughout its length.

Practical

The spongy portions of the bones are more commonly attacked by the various bacterial infections. The special localization of the infection is generally attributable to a neglected minor injury of the bone, while the individual is suffering from some infection with living bacteria circulating in the blood stream. The infection once

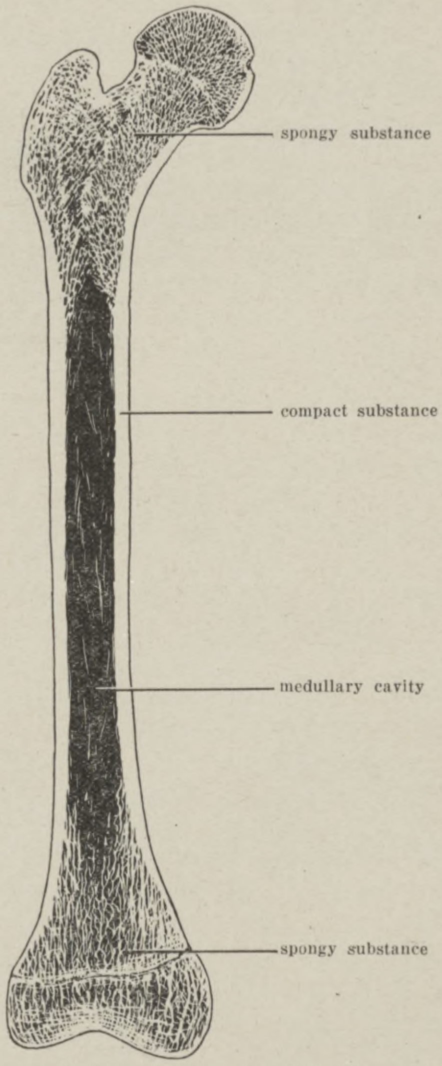

Fig. 28.—Longitudinal section of long bone (femur).

localized causes swelling, and due to the anatomic limitations of this process the blood supply is seriously interfered with. This causes local death or necrosis of the bone area. The diagnosis of these infections of the bone is to be made by the general symptoms of severe illness plus the localizing tenderness. The bone abscess, if neglected, may work its way into the neighboring joint, into the medullary cavity or onto the external surface of the bone. The obvious surgical procedure calls for the immediate free opening of the outer shell of the bone, eventually of the medullary cavity, in order to determine the most favorable line of least resistance. Although certain types of joint infection are unquestionably primary, many joint infections are secondary to diseases of the spongy substance of the bones.

CHAPTER IX

THE LOWER EXTREMITY

HIP AND THIGH

The part of the body composed of the hip, thigh, leg, and foot is known collectively as the lower extremity. The lower extremities possess bilateral symmetry, while the five pair of spinal nerves are the lasting evidence of their segmental origin. The lower extremity, as in the quadruped animals, is firmly attached by bones to the trunk, but the upright position of man has resulted in anatomic modifications

Hip Bone (Os Coxæ)

The bones of the hip girdle are developmentally made up of three distinct parts, but with the disappearance of the epiphyseal lines these three parts fuse into one solid piece. This fused hip bone was formerly known as the innominate, or nameless, for, on account of its irregularity, the imagination of former-time anatomists played out. The three original parts, known as the **ilium, ischium,** and **pubis,** join at the socket for the thigh bone, which is known as the **acetabulum,** or vinegar cup. The presence of cartilaginous lines in the bone allows for growth of the acetabulum, hence we would expect these lines, as in fact occurs, to disappear at the end of the growth period.

Pelvis

The two hip bones are held together in the midfront line by a very slightly movable joint known as the **symphysis pubis.** In back the hip bones are held apart by the presence of the sacrum, which is fastened to the iliac portions of the hip bones by very powerful interosseous ligaments. The combination of the two hip bones plus the sacrum and coccyx make up the pelvis or basin. This is subdivided into the part which has the shape of a basin, hence known as the **lesser** or true **pelvis,** and the flared-out iliac portions of the hip bones making the **greater** or false **pelvis.** It is to be especially noted that this true pelvis is not on a horizontal plane in the upright position of man, but that the plane of its brim is on over a fifty degree forward-downward slant. Or, in other words, the top of the symphysis pubis is about four inches lower than the top of the sacrum. The brim of the pelvis is known technically as the **apertura pelvis minoris superior.** These points can only be made out satisfactorily by the examination of an articulated bony pelvis, or by outlining the pelvis in the student's own body.

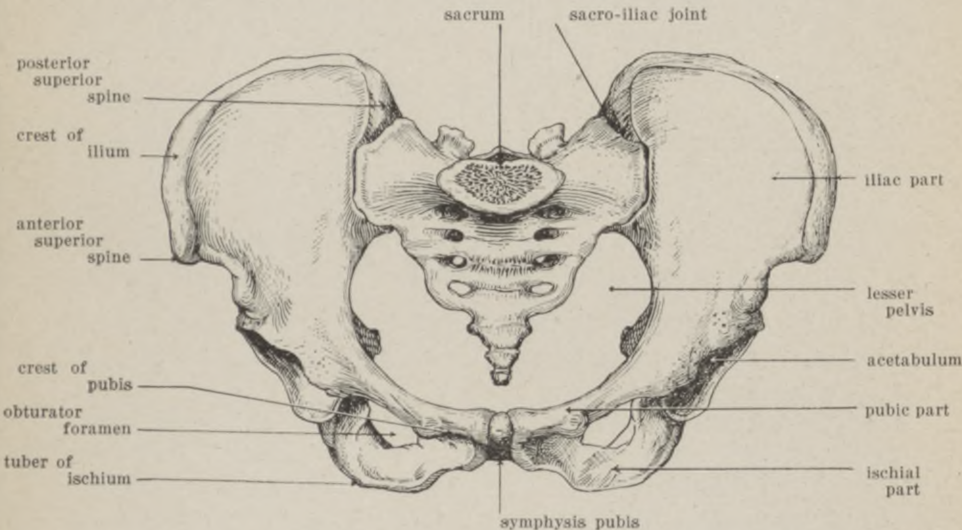

Fig. 29.—Female **Pelvis,** front view, tilted slightly forward.

Bony Landmarks

The bold, curving, irregular ridge of the hip bone above the hip joint is subcutaneous throughout and is known as the **crest of the ilium** or, more accurately, the crest of the iliac portion of the hip bone (ilium = flank). The terminations of the subcutaneous crest of the ilium are named the **anterior and posterior superior iliac spines,** which terminology naturally means that there are also anterior and posterior inferior spines. These will be more appropriately considered later. This iliac crest makes the surface separation between the abdominal region and the gluteal or buttocks region.

The ridge at the upper part of the symphysis pubis runs subcutaneously lateralwards for about one inch and is known as the **crest of the pubis**—that is, the pubic portion of the hip bone (pubis = covered by hair, as in the word puberty). This crest separates the front of the abdomen from the perineum, or region around the birth canal (peri = around; neum = new, hence birth). This seems like a reasonable explanation of the "neum," but the researches say the origin is uncertain or unknown. The bold, rough projection extending down below the hip joint on the medial side of the thigh is known as the **tuber of the ischium**—that is, ischial portion of the hip bone. This tuber or tuberosity separates the perineum from the lower part of the gluteal region.

The spines on the posterior surface of the sacrum are subcutaneous, while the lower part of the sacrum is covered only by a thick aponeurosis. The posterior surface of the coccyx is subcutaneous.

Ligaments

A narrow ligament runs from the anterior superior spine of the crest of the ilium to the nearest point of the crest of the pubis, raising up the pubis tubercle at its attachment. This is known as the **inguinal** or as **Poupart's ligament** (inguen = groin). The inguinal ligament separates the lower part of the abdominal wall from the front of the thigh.

A wide ligament starts from the lateral margin of the sacrum, converges in its midportion, and widens out again near its attachment to the tuber of the ischium. This is known as the **sacrotuberous** or greater sacrosciatic **ligament.** The word sciatic is used practically as a synonym of ischiadic, though ischiadic is preferred in the B. N. A. A fairly wide ligament starts from the lateral margins of the sacrum and converges at its attachment to the ischium, about one and one-half inches above the tuber of the ischium, raising up the **spine of the ischium.** This is known as the **sacrospinous** or lesser sacrosciatic **ligament.** The large open space between the sacrum and the ischium is converted by these ligaments into the **greater and lesser sciatic foramina.** The greater sciatic foramen forms a passageway between the lesser or true pelvis and the gluteal region. The lesser sciatic foramen serves as a passageway between the gluteal region and the perineum, as will be detailed later.

Obturator Foramen

The obturator foramen is a large, oval opening between the true pelvis and the medial portion of the upper part of the thigh (obturator = closed). This window exists at the expense of the pubic and ischial portions of the hip bone, an interosseous membrane stretching across this space during life. The narrowed portions of the pubic and ischial bones are known as the **rami** or branches, which for obvious reasons were formerly differentiated into an ascending and descending ramus of the pubis and an ascending ramus of the ischium. In the revised nomenclature the ascending ramus of the pubis is known as the superior, the descending as the inferior, while the ascending ramus of the ischium is known as the inferior. Fractures of the pelvis commonly pass through these rami on account of their relative weakness. The symphysis pubis and the two sacro-iliac amphiarthrodial joints give elasticity to the pelvis and consequently minimize the frequency of fractures.

The Femur

The femur or thigh bone is a typical long bone. It has a rounded **head,** which fits into the acetabulum, forming a ball and socket joint. A relatively long **neck** runs off on a downward lateralward slant, carrying the shaft well away from the hip bone. The large roughened projection on the lateral side of the upper end of the shaft is known as the **greater trochanter.** The use of the word "trochanter" instead of tuberosity in connection with the femur is historically established, but, is in my opinion, unnecessary, being a distinction without a difference. The greater trochanter is many faceted on account of muscle insertions, whereas the **lesser trochanter** on the medial posterior surface serves for the attachment of a single tendon. Down the posterior surface of the femur run a series of parallel sharp lines or **linea aspera,** which are raised up by muscle aponeurosis and fascia sheets. The widened-out lower end of the femur has a **lateral and medial condyle,** which articulate with the tibial bone of the leg to form the knee joint. The projections from the condyles raised up by tendons are known as the lateral and medial epicondyles.

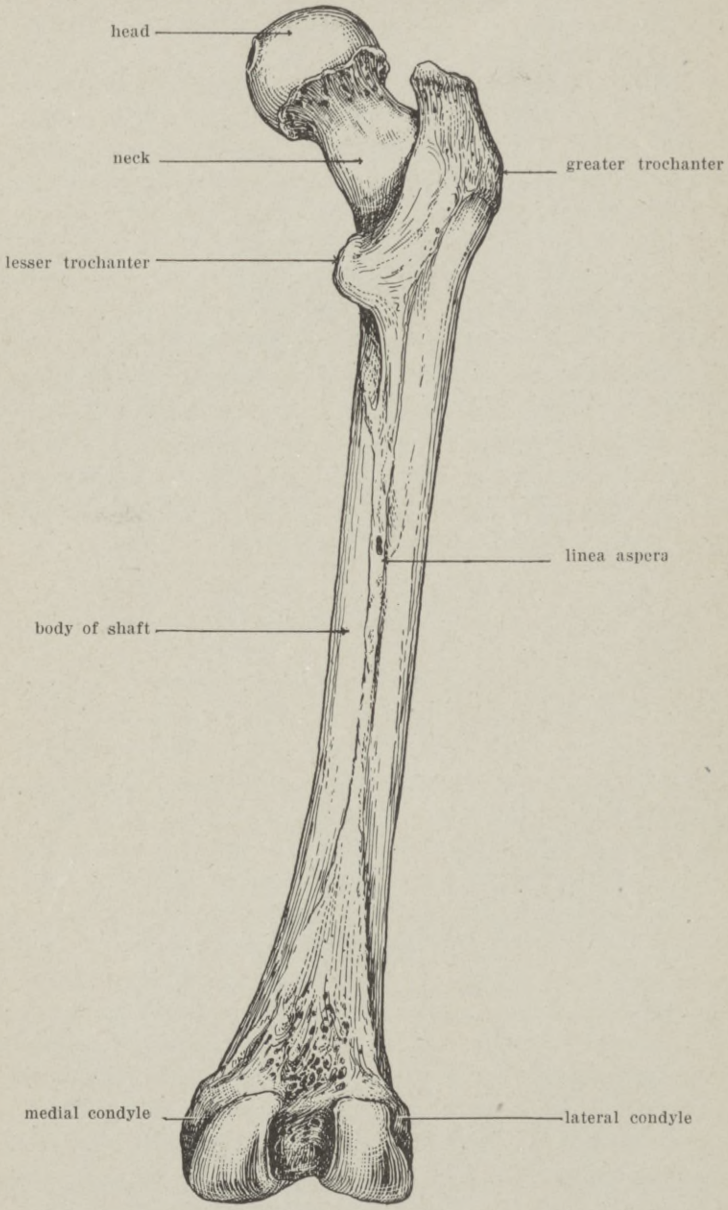

Fig. 30.—Left **Femur**, posterior surface.

Gluteal Region

The body is to be turned upon its belly in order to examine the gluteal region. The main bony landmarks are the crest of the ilium, the tuber of the ischium and, somewhat covered by muscle aponeurosis, the greater trochanter of the femur. The sacrum and the coccyx are also landmarks, but the sacrotuberous ligament is so heavily covered by muscle that it can only be made out by deep palpation.

The skin is thick and tough, while the subcutaneous fatty layer, except for its thickness, is as routine. A bursal sac should be noted between the skin and the tuber of the ischium. After removing the skin and fatty layers the powerful muscles, covered by their strong deep fascia, may be outlined.

Gluteus Maximus Muscle

The gluteus maximus muscle arises from the posterior fifth of the crest of the ilium and from the sides of the sacrum and coccyx. Running in parallel strands downward and lateralward, its upper fibers insert into the lateral deep fascia of the thigh and its lower fibers into the lateral crest of the linea aspera, upper fifth. It is a thick, powerful muscle, its lower fibers covering the sacrotuberous ligament, thereby extending into the perineum. The aponeurosis runs over the greater trochanter of the femur, a bursa lying between these two structures. This muscle acts as an external rotator and also as an extensor of the thigh.

The gluteus maximus should be cut across about its middle and its fibers turned back towards their origin and insertion. By this dissection the great majority of gluteal structures are exposed to view.

Ischiatic, or Sciatic, Nerve

The large flat nerve cord just lateral to the tuber of the ischium is the ischiatic, or sciatic, nerve, which is the main continuation of the lower extremity nerve plexus. The lower extremity plexus is composed of spinal segmental nerves from the fourth and fifth lumbar, and the first, second, and third sacral intervertebral foramina.

Processes of the sympathetic nervous system join the lower extremity plexus, just as has been previously detailed in connection with the upper extremity nerve plexus. These sympathetic nerves control the involuntary activities of the lower extremity and make the same segmental connections as the peripheral nerves proper. Many of the sympathetic processes travel along the fascial compartments of the arteries, while the bulk join the lower extremity plexus en route towards their terminations.

In the sitting posture, in spite of its depth, the sciatic nerve is subject to pressure, as is popularly recognized in the "gone-to-sleep" feeling of the lower extremity. At one stage of development it is accompanied by the main artery and vein of the lower extremity, but presumably due to this exposed position these original vessels disappear, while the anastomosis in front becomes the main trunk. This sciatic nerve comes out of the lesser or true pelvis through the greater sciatic foramen.

Internal Rotator Muscles

The powerful **gluteus medius** muscle arises just below the crest of the ilium over the anterior four-fifths of the outer surface of the bone, and converges onto a tendon running downwards and backwards to its insertion onto the greater trochanter of the femur. The **gluteus minimus** arises from the outer surface of the hip bone under the gluteus medius and, following approximately the same course, inserts into a separate facet of the greater trochanter. The anterior fibers of these muscles have a special function as internal rotators of the thigh. The action of the three gluteal muscles acting together would be negative as regards rotation, but on account of their origins being above their insertions they would cause abduction of the thigh.

These muscles should be cleared and examined.

Special External Rotators

The **pyriformis** arises from the ventral surface of the sacrum, enters the gluteal space through the greater sciatic foramen, and in common with the other muscles of this group runs in back of the hip joint to its attachment to the greater trochanter of the femur (pyriformis = pyramid-shaped).

The smaller vessels and nerves for the regional supply coming out above the pyriformis are known as the gluteal, whereas those below are the sciatic.

The **obturator internus** arises on the inside of the obturator foramen, leaves the perineum through the lesser sciatic foramen, and crosses deep to the sciatic nerve to its attachment to the femur. Two little muscle bellies attaching to the upper and lower border of this tendon are known as the gemelli, or twin muscles.

The **obturator externus** arises on the outside of the obturator foramen and runs closely applied to the back of the hip joint-capsule to its insertion.

The **quadratus femoris** arises from the lateral surface of the tuber of the ischium, is approximately square, as its name implies, and inserts onto the femur. These four muscles running in back of the hip joint to their insertion into the femur necessarily act as external rotators.

These muscles should be cleared and examined.

Thigh Region (Regio Femoralis)

The femur is heavily covered by muscles, not quite so thick, to be sure, over its anterior and lateral surfaces, but still liberally covered. At the upper end the greater trochanter of the femur is covered only by the aponeurosis of the gluteus maximus muscle and hence is practically subcutaneous. At the lower end of the femur, where the muscle bellies give way to tendon, the lateral and medial condyles are readily palpable. The skin follows the general rule of being thicker over the lateral exposed sides and thinner over the medial more protected parts. It is especially thin over the **popliteal** or back of the knee region.

The skin is to be dissected off to below the knee.

Subcutaneous Fatty Layer

The subcutaneous areolar layer is of average thickness and contains the routine cutaneous arteries, veins, and nerves. The superficial venous system is represented by one main trunk, which runs up the medial side of the leg and thigh to a point about one inch below the inguinal ligament, and about one inch lateral to the pubic spine. This **large saphenous** vein receives smaller branches from various directions, and dips down through the saphenous opening in the deep fascia to join the femoral vein. The corresponding small saphenous vein will later on be noted to dip through the deep fascia in back of the knee. A series of lymph vessels, as is usual, run in close association with the large saphenous vein. The lymphatic glands of these vessels are practically all grouped about the saphenous opening, which explains the enlargement of this region found in association with infection or malignant growths of the lower extremity. Over the region in the neighborhood of the inguinal ligament lie a group of lymphatic glands, which belong more directly to the lymphatic vessels of the external genitalia. Anatomically the characteristic unusual feature of these groups is the fact that they lie chiefly in the subcutaneous fatty layer. As a result, when they are unable to handle the infection and break down, the pus pocket lies much nearer the surface than is usual in lymphatic gland abscesses of other parts of the body.

This layer should be dissected and then removed.

Deep Fascia

The deep fascia, as is usual, encircles the thigh and eventually attaches above around the pelvic bones and below to the bones in the neighborhood of the knee. It is, as would be anticipated, very much more powerful over the lateral side of the thigh than over the medial side. Fact is, on the lateral side it is the strongest deep fascia of the body and receives the special name of **fascia lata** (lata = broad). This fascia lata may be considered in part as an aponeurosis, inasmuch as part of the gluteus maximus muscle attaches to it. A muscle known as the **tensor fascia latæ** arises near the anterior superior spine of the iliac crest and, running straight down between two folds, inserts this fascia. The deep fascia further sends in intergroupal septa between the muscle groups which attach to the linea aspera, marking off the compartments of the thigh.

Adductors of Thigh

The adductor muscle group arises from the body of the pubic bone and the rami of the pubis and ischium, and runs downward and lateralward to its insertion into the linea aspera of the femur. Owing to the fact that the linea aspera is on the back surface of the femur, this group also possesses some power as external rotators.

The **pectineus** arises from the top of the superior ramus of the pubis and, following a downward and lateral course, inserts into the upper sixth of the linea aspera (pectineus = comb-like).

The adductor longus arises from the body of the pubis and, paralleling the pectineus, inserts into the linea aspera below this muscle, extending somewhat below the middle of the thigh.

The **adductor brevis** arises from the body of the pubis and, running on a deeper plane, inserts into the linea aspera behind the mid-sections of the two preceding muscles.

The **adductor magnus** arises over a large area of the rami of the

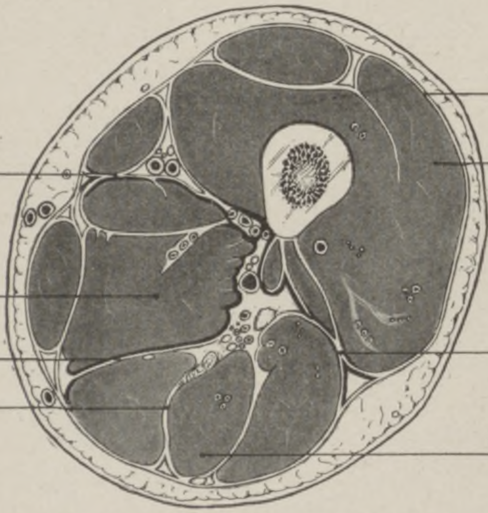

Fig. 31.—Fascial compartments at middle of Thigh.

pubis and ischial bones, lies on a deeper plane, and is a large, powerful muscle. It follows the same general course and inserts into the linea aspera throughout the lower two-thirds, extending down to the medial condyle.

The **gracilis** is a strap-like muscle, arises from the subcutaneous edge of the rami of the pubis and ischium, and inserts into the medial front surface of the tibia just below the knee.

Nerve Supply

The nerve supply of this group comes from the lower extremity plexus, but does not join the sciatic trunk. The nerve takes a separate divergent course through the obturator foramen, hence is called the obturator nerve. The arterial supply is from branches of the profunda femoris, as will be detailed later on.

This group of muscles and their nerve supply should be cleared.

Flexors and Extensors of Thigh

The large tendon of the powerful **iliopsoas** muscle comes out of the abdominal cavity over the iliac part of the hip bone, medial to its anterior superior spine, runs in front of the capsule of the hip joint and inserts into the lesser trochanter of the femur. This point lies to the back and medial side of the upper part of the femur, so that when this tendon is pulled upon, flexion of the thigh will be produced, plus a certain amount of external rotation. The psoas portion arises from the sides of the bodies of the lumbar vertebræ, whereas the iliac portion arises from the inside of the ilium and joins the psoas tendon, the iliac muscle belly being readily demonstrable in the upper part of the thigh. This is a strong, powerful muscle, but its origin can not be seen until after the abdominal cavity has been opened. Other muscles of the front compartment, arising from the pelvis and running into the thigh, incidentally act as accessory flexors of the thigh.

The main extensor of the thigh is the gluteus maximus muscle, as previously noted. Other muscles of the back compartment incidentally act as accessory extensors.

Extensors of Leg

The muscles of the group in the front compartment of the thigh are chiefly extensors of the leg. The main muscle, considered as a whole, is known as the quadriceps or four-headed extensor. The straight central portion, the **rectus femoris**, arises from the anterior inferior spine of the ilium and joins the common tendon. On each side, arising from ridges of the linea aspera, are large muscle bellies, the **vastus lateralis** and **medialis.** The **vastus intermedius** division arises from the greater part of the front of the femur and inserts into the common tendon. These four bellies come together into a common tendon, which, passing in front of the knee, eventually is continued onto the tibia, raising up the tibial tuberosity. A piece of porous bone, the **patella**, or knee-cap, is developed in this tendon.

Bones developed in tendons are technically known as sesamoid bones (sesamoid = like a seed). The patella serves to hold the tendon away from the joint and allows the tendon to work at less mechanical disadvantage. Some of the quadriceps tendon passes over the patella, but the bulk inserts into the patella, and a new portion, known as the ligamentum patella, runs to the tibial tuberosity. The main function of this group is to extend the leg, which, as a matter of common knowledge, works on a short-lever, rapid-action principle. Inasmuch as the rectus division arises from the pelvis, this muscle group has also some power as a flexor of the thigh.

The **sartorius** is a narrow strap-like muscle running from the anterior superior spine of the ilium diagonally, medially, and downwards to its insertion on the medial front surface of the upper part of the tibia (sartor = tailor). Inasmuch as it runs from the pelvis through the femur to the leg, its action is complicated and varies with the circumstances.

Nerve Supply

This group of muscles, with the overlying skin and underlying bone, receives its nerve supply from the lower extremity nerve plexus. The nerve takes a separate divergent short cut over the iliopsoas muscle to the area. It was formerly named the anterior crural, a misnomer, as crural means leg, in contradistinction to thigh. It is now known as the femoral nerve. The blood supply from the profunda femoris will be considered in a special paragraph.

The extensor group of muscles and its nerve supply should be cleared.

Flexors of Leg

The muscles of the group in the posterior compartment of the thigh are chiefly flexors of the leg. The three muscles arise from a common tendon on the ischial tuber and, running past the knee, insert into the tibia and fibula. The **biceps** femoris diverges to the lateral side and the lower end, reinforced by a short head arising from the linea aspera, inserts into the head of the fibula. The **semimembranosus** runs to the medial side and attaches in back of the tibia just below the knee. The **semitendinosus** runs in close proximity to the semimembranosus, but continues to the front medial surface of the tibia. The insertions of the sartorius, gracilis, and semitendinosus are grouped on the surface of the tibia. Inasmuch as these muscles pass the knee along its posterior medial surface, they act as flexors and also as accessory rotators of the leg. While the biceps, semitendinosus, and semimembranosus are flexors of the leg, it should be noted that they are also extensors of the thigh. Further, inasmuch as they arise from the pelvis, they have the power of moving the pelvis on the thigh or the thigh on the pelvis, as the special requirements may call for. The sciatic nerve runs deep under these muscles and, incidentally, sends off the branches for the area.

Just as in the case of the biceps muscle of the arm, there are many complicated muscles in the thigh which pass from the pelvis through the thigh to the leg. Embryologically, the muscles are much simpler, passing only from the pelvis to the thigh and from the thigh to the leg. The complicated muscles are the rectus femoris, sartorius, gracilis, semitendinosus, semimembranosus, and the biceps.

This flexor muscle group and its nerve supply should be cleared.

Fossa Poplitea

The popliteal pit is the name given to the area in back of the knee. It is an important region, because the main vessels and nerves of the leg take this protected channel in their course past the knee. The small saphenous vein of the superficial venous system pierces the deep fascia about the center of the region en route to the popliteal vein. The divergent tendons of the biceps on the lateral side and the semimembranosus and semitendinosus on the medial side form an upper triangle. The converging heads of the gastrocnemius muscle of the leg form a lower triangle (gastro = belly; nemius = calf). These two triangles considered together make up a diamond-shaped space, which is covered over by strong, deep fascia. Just under the fascia lie the two terminal subdivisions of the sciatic nerve. The **popliteal artery** lies against the bone, while the **popliteal vein** lies on its superficial surface. The further details of this area will be considered in connection with the vessels and with the leg area.

The deep fascia should be split longitudinally, and the major structures cleared and identified.

Blood Supply of Thigh

Originally there were five pairs of segmental arteries, veins, and nerves, corresponding to the five segments of the lower extremity as represented in the adult by the five toes. In the next stage of embryonic development the main artery and vein accompany the sciatic nerve. Presumably due to their exposure to pressure, the main arterial and venous trunks become an anastomosis, while the original anastomosis down the front protected area of the thigh become the main trunk. This vessel, after it passes under the inguinal ligament of Poupart, is known as the **femoral artery,** the femoral vein lying along its medial side. In this area the vessels lie close to the surface in Scarpa's triangle. Scarpa's triangle is bounded by the inguinal ligament and by the sartorius and adductor longus muscles. The vessels next dip under the sartorius muscle, following it as a guide. At about the middle of Scarpa's triangle the branch is given off which is to subdivide to supply the whole thigh region, the **profunda femoris.** The femoral artery continues through Hunter's canal, under the sartorius muscle, into the protected popliteal space. As per routine, lateral and medial articular anastomosing branches are given off above and below the knee, while a single branch enters the knee joint.

The **profunda femoris,** as the name implies, works down close to the medial side of the femur. It sends off at progressively lower levels four paired branches, which encircle the femur, hence known as the circumflex or, inasmuch as they perforate the intergroupal fascial septa, as the perforating arteries. These vessels supply the whole thigh, and anastomose above with the sciatic and gluteal vessels. The deep venous system corresponds to the arterial, with the usual exception that all the smaller arteries have paired venæ comitantes. The great saphenous vein of the superficial venous system has been considered with the fatty layer dissection.

The vessels should be cleared.

Hip Joint (Articulatio Coxæ)

Dissect off all the muscles holding the femur to the trunk, taking care not to open the capsule of the hip-joint. The head of the femur will remain firmly in the acetabulum, and in this large joint will even resist considerable traction. This is a typical factor in every joint and is due to the suction action of the vacuum. In a midrange position the capsular ligament is necessarily nowhere really tense, so that in such a position the capsular ligament does not hold the bones together. The muscles, however, more especially if they were slightly or markedly contracted, would hold the bones in firm apposition.

The extra thickened, powerful front portion of the capsular ligament may be brought into relief by manipulation. The thickened portion arises from the anterior inferior spine of the ilium and inserts into the anterior intertrochanteric line. This **iliofemoral ligament,** on account of its shape, was formerly known as the inverted Y ligament. When the normal body is erect the center of gravity falls just behind the center of the hip joint, and consequently this ligament takes the strain off the muscles of the thigh in standing.

The capsular ligament may then be cut, encircling the neck of the femur. A **ligamentum teres** will be noted, attaching the head of the femur to the acetabulum (teres = round). This usually contains fibrous tissue of considerable strength, which resists excessive range of motion, perhaps the most important of which is its resistance to extreme abduction. Another function consists in carrying an anastomosing blood supply to the head of the femur. This ligament should be cut across and the limb removed. The acetabular socket should be noted to be built out by a cartilaginous rim and to have a depressed area for the ligamentum teres. Towards the obturator foramen a small opening for vessels to the ligamentum teres should be noted.

Dislocation

The depth of the socket would make dislocation accidents seem very unusual. The so-called congenital dislocations of the hip are explicable on the ground of relative shallowness of the acetabulum in early childhood. It is probable that some of these dislocations occur during the process of birth. The iliofemoral ligament is practically never torn in dislocations and hence is used as a lever to pry the head back into the socket. Dislocation, just as in the case of the shoulder joint, is more readily produced in extreme abduction. On account of the strength of the muscles and ligaments a pull on the leg, no matter how strong or sudden, would never put a serious strain on the lower extremity nerve plexus. "Pulling the leg" is anatomically, at any rate, less dangerous than pulling the arm.

Practical

An infection of the hip joint, unless the pain sense is destroyed, results in contraction of all the muscles controlling the hip, the position assumed by the thigh depending upon the relative strength of the muscle groups. The characteristic position assumed under these circumstances is flexion, external rotation, and adduction, due to the fact that those groups are markedly stronger than their opponents. Fractures of the neck of the femur are more common in the brittle bone of old age. They usually occur following a fall on the greater trochanter of the femur. The position assumed by the leg is very similar to the picture of infection of the hip, with the additional symptom of shortening, as the muscle contraction causes an overriding of the fragments. The seriousness of this injury is due more to the general lack of resistance and bone-building power than to the accident itself.

LEG AND FOOT (CRUS ET PES)

Tibia and Fibula

The leg is, anatomically speaking, that part of the lower extremity which extends from the knee to the ankle. The large medial bone has a broad subcutaneous surface, carries the bulk of the weight of the body, and is known as the tibia or, popularly, the shin bone. The fibula, as the diminutive "ula" ending indicates, is the smaller lateral bone, which, except for its upper and lower portions, is covered by muscles. At the lower end on each side of the ankle joint the rounded projections extending down are known as the **malleoli,** medial and lateral. Although given the special name malleoli, they are of the type of projections generally known as condyles. Inasmuch as the term **condyles,** medial and lateral, is applied to the widened-out upper part of the tibia at the knee joint, a repetition of the same term at the lower end would lead to confusion. Between the opposing surfaces of the tibia and fibula runs an interosseous membrane, which, as would be anticipated, raises up ridges of attachment. The intergroupal muscular septa raise up two additional ridges on the fibula, as will be detailed in the consideration of the fascias of the leg. These bones are typical long bones, both in development and structure.

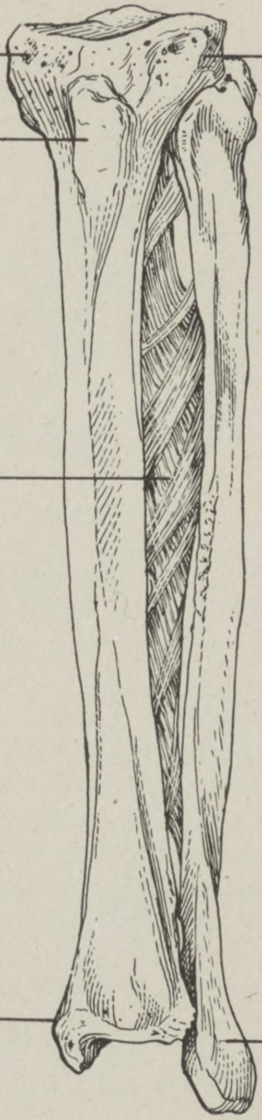

Fig. 32.—Left **Tibia** and **Fibula**, anterior surface.

Tarsal, Metatarsal, and Phalangeal Bones

Inasmuch as most of the muscles of the leg extend into the foot, the tarsal, metatarsal, and phalangeal bones may well be considered at this time. The tarsal bones are held firmly together by dorsal, interosseous, and plantar ligaments. The bone held between the malleoli of the tibia and fibula, and with them making up the ankle joint, is known as the **talus** or astragalus. The bone extending back from the under surface of the talus into the heel is known as the **calcaneus** or os calcis. Continuing the medial column of the foot forwards from the talus are found the **navicular** (O. T. scaphoid) and the three **cuneiform** or wedge-shaped bones. Continuing the lateral column of the foot forward from the calcaneus is found the **cuboid** bone. Running forward from the cubocuneiform irregular line are the five metatarsal bones. Then follow the phalanges, three in number for every toe, except the great toe, which has only two. The tarsal, metatarsal, and phalangeal bones can be readily palpated, except on the surface—that is, the sole of the foot.

Developmental Rotation

The sole of the foot obviously corresponds to the palm of the hand, while the top of the foot corresponds to the back of the hand. In this fully developed anatomic position the big toe side lies medially, while the corresponding thumb side lies laterally. During one stage of development both the big toe side of the foot and the thumb side of the hand are the ventral surfaces. A secondary rotation inwardly of ninety degrees carries the big toe side of the foot, leg and thigh towards the midline of the body, while a rotation outwardly of ninety degrees carries the thumb side of the hand, forearm and arm away from the midline to its adult position. Anatomically the hand is always considered in the supine position, that is with the thumb lateralward. The top of the foot has been given the misnomer dorsum, whereas it is in reality the superior or even the ventral surface of the foot. This anatomic nomenclature variation, however, is worthy of being retained as it emphasizes the developmental changes and brings out the comparisons. The ventral compartments of the arm, forearm, and hand in the fully developed status contain the flexor muscles, while as a result of rotation,

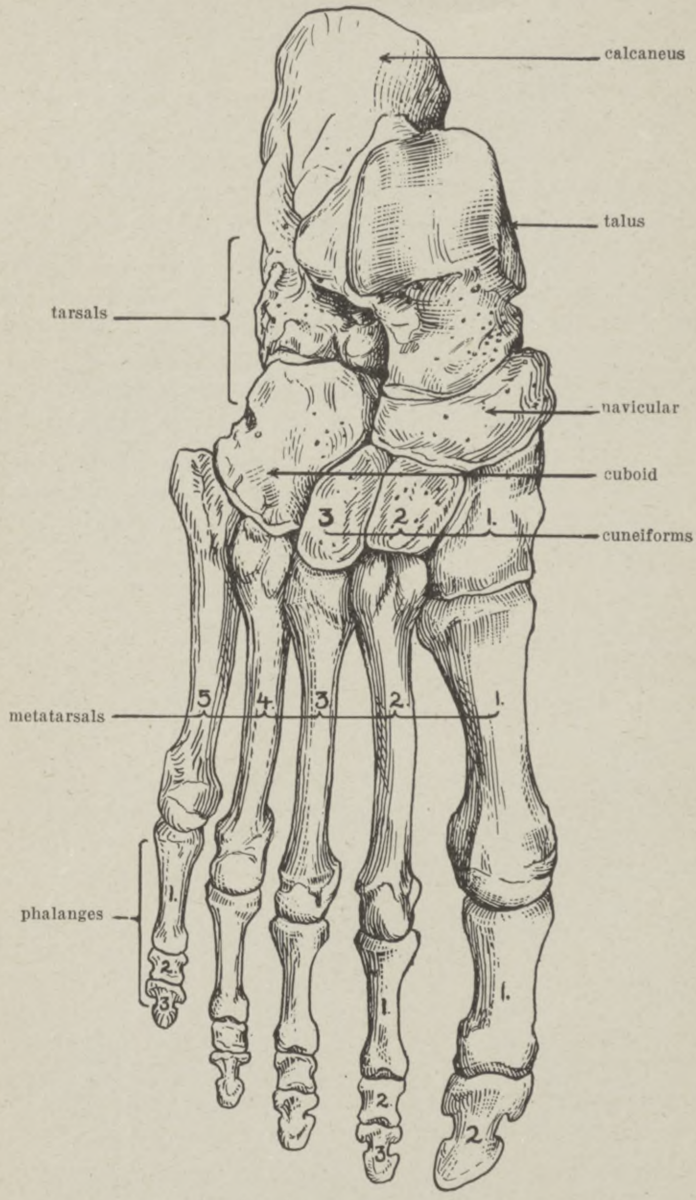

Fig. 33.—Right **Foot** (pes) superior or dorsal surface.

the ventral compartments of the thigh, leg, and foot contain the extensor muscles.

Skin

The skin is fairly equally exposed and consequently of approximately equally tough texture on all sides of the leg. On the dorsum of the foot the skin is delicate, while at the ends of the toes the nails are to be noted. On the plantar surface of the foot the skin is as would be anticipated especially thick and tough. The epidermis of the plantar surface is especially thickened, more markedly so over the bony prominences. Callous forms in this layer over the bony projections, and if the pressure is kept up more or less continuously, the resulting painful calluses are popularly known as corns. Neither hair nor sebaceous glands are present over the sole of the foot.

The skin should be dissected off from the leg and foot.

Subcutaneous Fatty Layer

The subcutaneous fatty layer is not characteristic over the leg or dorsal surface of the foot, but is greatly toughened over the central compartment of the sole, as would be expected from analogy with the palm. Cutaneous arteries, veins, and nerves branch from the regional trunks. Considerable tactile sense, although ordinarily not trained, lies latent in the pulp of the toes, as the relatively large size of the nerves bear witness. The superficial venous system on the top or dorsum of the foot runs off into two main trunks, the great and the small saphenous. The greater crosses the lower end of the tibia and takes the posterior edge of the tibia as its guide to beyond the knee. The lesser saphenous runs in back of the fibular malleolus, progresses towards the midline of the leg, and terminates in the popliteal vein.

This layer should be dissected off.

Deep Fascia

The deep fascia arising at one subcutaneous border of the tibia, encircles the leg, and attaches to the other border of the same bone. Over the fibula the fascia sends two intergroupal septa down to the bone, separating off a small fibular or peroneal compartment. The leg is therefore considered as having four compartments, a **tibial** and a **fibular,** and, separated by the interosseous membrane, an **anterior** and a **posterior tibio-fibular compartment.** Over the lower part of the front compartment of the leg, where the muscle bellies give way to tendon, the thickened portion of the deep fascia is called the **transverse crural ligament.** The thickened portion across the dorsum of the foot is known as the cruciate or cross ligament. On each side bridging from the malleoli to the calcaneus the thick-

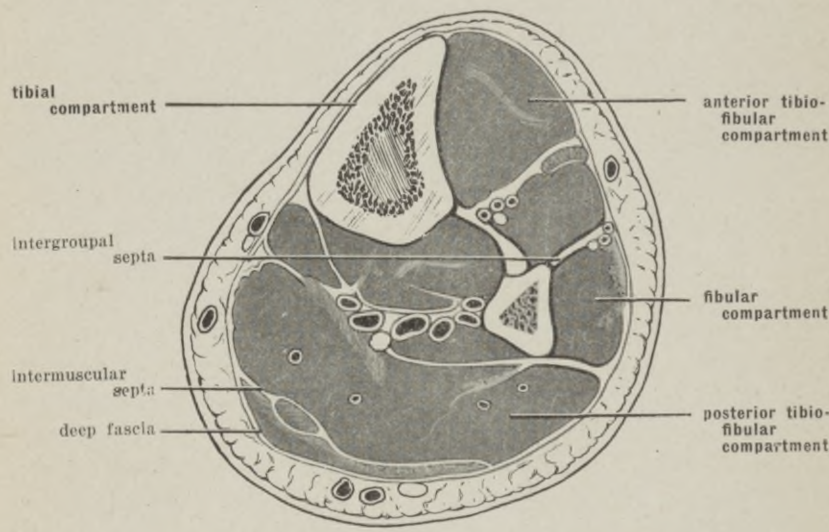

Fig. 34.—Fascial compartments at middle of Leg (crus).

ened portions of the deep fascia might be identified as the **lateral** and **medial crural ligaments.** (B. N. A. retinaculum musculorum peroneorum sup. et inf.—ligamentum laciniatum.) Over the central compartment of the sole of the foot the deep fascia or plantar aponeurosis is especially thick and tough. When pus gathers in the sole of the foot the strong fascias prevent much swelling of the region, while the loose tissues on the back of the foot swell markedly. Tenderness on deep pressure makes clear the diagnosis and calls for an incision through the deep fascia. The deep fascia serves to protect the more vulnerable deeper structure. The flexor tendons are held down by the specialized deep fascia tubes, which make up the synovially lined **flexor tendon sheaths** (ligamenta vaginalia).

Anterior Tibiofibular Compartment and Dorsum of Foot

In the anterior tibiofibular compartment lie three main muscles, named the extensor digitorum longus, the extensor hallucis longus and the tibialis anterior. The front of the leg corresponds anatomically to the back of the forearm, as during development, as previously detailed, a rotation of a half-circle takes place. The **extensor hallucis longus** arises from the lateral surface of the tibia in front of the interosseous membrane and inserts into the second or terminal phalanx of the big toe (hallux = great toe). The **extensor digitorum longus** arises mainly from the fibula, separates into four tendons near the ankle, terminating on the second and eventually third phalanges of the toes. A small slip from this muscle, known as the peroneus tertius inserts into the base of the fifth metatarsal. The **tibialis anterior** arises mainly from the tibia and inserts into the medial side of the first cuneiform. This muscle, therefore, inverts the foot across the tarsal joints. These muscles should be noted to arise not only from the bone and interosseous membrane, but also from the deep fascias of the area as is a widespread occurrence in muscle origins.

The small muscle arising over an area just in front of the malleolus of the fibula is the **extensor digitorum brevis.** This muscle sends a tendon to all the toes except ordinarily the little toe. The part of this muscle running to the dorsum of the great toe is called the **extensor hallucis brevis.**

The deep fascia should be split open in order to dissect out these muscles, noting particularly the thickened portion in front of the ankle region. These ligaments consist of a transverse portion between the tibia and fibula, and a diagonal portion over the dorsum of the foot.

Tibial Compartment

The tibial compartment is subcutaneous, except in its uppermost part, where the tendons of the quadriceps and of the sartorius, gracilis and semitendinosus insert. Various bone diseases tend to localize in the tibia following minor traumata on account of its exposed position without muscle covering.

Fibular Compartment

The fibular compartment contains two muscles, which arise from the fibula and septal fascias. They run in back of the fibular malleolus under the lateral crural ligament, then go forward and downward to the lateral margin of the foot. The **peroneus brevis** attaches to the lateral side of the base of the fifth metatarsal. The **peroneus longus** runs around the lateral border of the foot into the sole and spreads out at its insertion into the first cuneiform and base of the metatarsal bones. These peroneus muscles act as everters of the foot.

These muscles should be cleared to the lateral margin of the foot.

Posterior Tibiofibular Compartment

The posterior tibiofibular compartment contains two groups of muscles, well separated by an intergroupal fascial septum. The superficial group is really a triceps muscle, for the muscleheads come together into the common Achilles or calcanean tendon. The lateral and medial **gastrocnemii** heads arise from the back surfaces of the lateral and medial condyles of the femur respectively. The **soleus** head lies underneath the gastrocnemii, arises from the posterior surface of the tibia and fibula throughout their upper halves, and joins the common tendon in the lower third of the leg. The Achilles common tendon inserts into the posterior upper surface of the calcaneus, therefore, the essential action of the muscle is flexion of the foot.

The deep group is made up of a **flexor digitorum longus** and a **flexor hallucis longus,** arising from the tibia and fibula, respectively, and running under the medial crural ligament into the sole of the foot. In the sole of the foot the flexor hallucis longus tendon sends a slip to join the flexor digitorum longus tendon, consequently the flexor hallucis longus acts a flexor of all the toes. The course of these muscles to the terminal phalanges of the toes in special flexor sheaths is the same as the deep flexors in the palm of the hand. The **tibialis posterior** arises from both bones and the interosseous membrane, and runs to a tubercle at the medial inferior surface of the navicular bone. It, therefore, acts as an inverter of the foot.

These muscles should be cleared to the sole of the foot.

Sole of the Foot

Three muscles arise near the heel and run forward in the superficial layer in special fascial compartments. In the center compartment lies the **flexor digitorum brevis,** which, dividing for the four toes, enters the flexor tendon sheaths. Just as in the palm, each superficial tendon splits to allow the deep flexor to pass through and inserts into the sides of the second phalanx. The lateral compartment contains the **abductor digiti quinti,** which runs to the base of the first phalanx of the little toe. The medial compartment contains the **abductor hallucis,** which runs to the base of the first phalanx of the big toe.

The second layer of the sole is made up of the flexor tendons in their course to the toes. The flexor longus digitorum tendon is joined by the **quadratus plantæ** muscle from the calcaneus and by **lumbricle** muscles arising from the first phalanx of the four outer toes. These muscles tend to steady the main tendon in its movements and to keep it pulling in a proper line.

The third layer is composed of intrinsic small muscles of the first and fifth toes. These small muscles are an adductor hallucis, a flexor hallucis brevis, and a flexor digiti quinti brevis. Between the metacarpals lie the **interossei** muscles, the dorsal group acting as abductors in relation to the midline of the foot, the plantar group as adductors.

The muscles in the sole of the foot should be dissected out, layer by layer. The tendon of the peroneus longus muscle should be traced through its synovial sheath to its spread out insertion under the cuneiform and base of the first metatarsal bone.

Vessel Supply

The popliteal artery divides just below the knee into the anterior and posterior tibial branches. The **anterior tibial artery** runs forward through the interosseous membrane, goes deep through the anterior tibiofibular compartment, and when the muscle bellies give way to tendon, becomes superficial over the dorsum of the foot, where it receives the regional name **dorsalis pedis.** The **posterior tibial artery** sends off a large peroneal or fibular branch, and continues down with the deep muscle group, eventually following the muscle tendons into the sole of the foot. It is, as would be anticipated on account of the muscle bulk to be supplied, much larger than the anterior tibial. In the sole of the foot the posterior tibial artery divides into **medial** and **lateral plantar** branches, which vessels run along the intergroupal septa of the first layer of the sole.

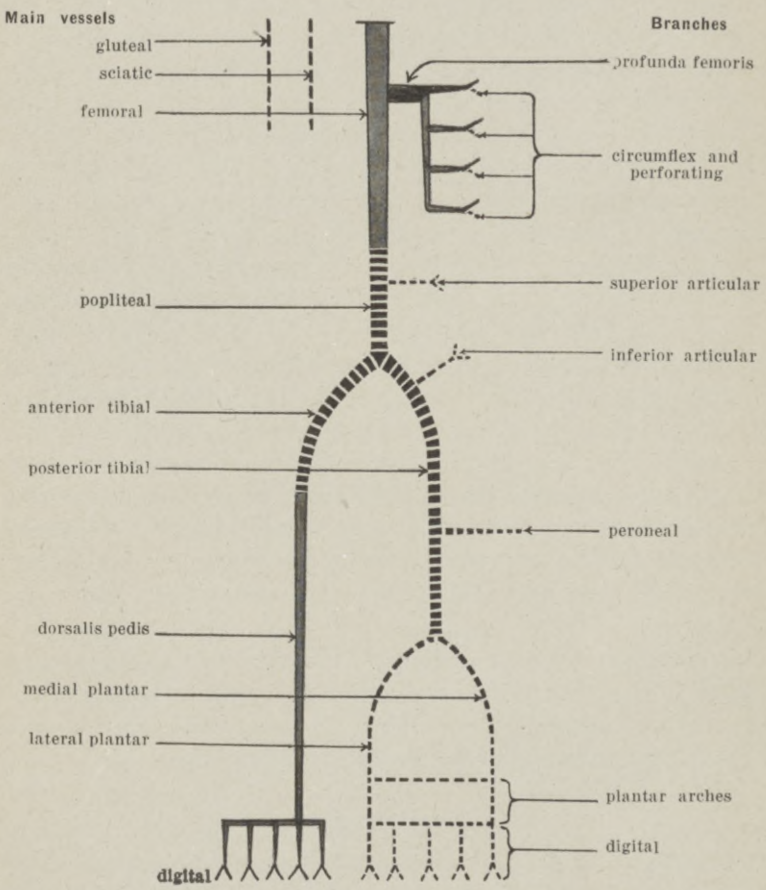

Fig. 35.—Diagram of Arteries of lower extremity. (Dotted lines are parts in posterior compartments.)

These plantar arteries make small superficial and deep plantar arches with digital branches, superficial and deep to the flexor tendons. As usual about a joint, a free anastomosis is found at the ankle, in simplest terminology to be known as the superior and inferior articular anastomosing branches.

Nerve Supply

The entire nerve supply below the knee is carried by the sciatic nerve, with the exception of some minor cutaneous branches following the course of the great saphenous vein. The **common peroneal**

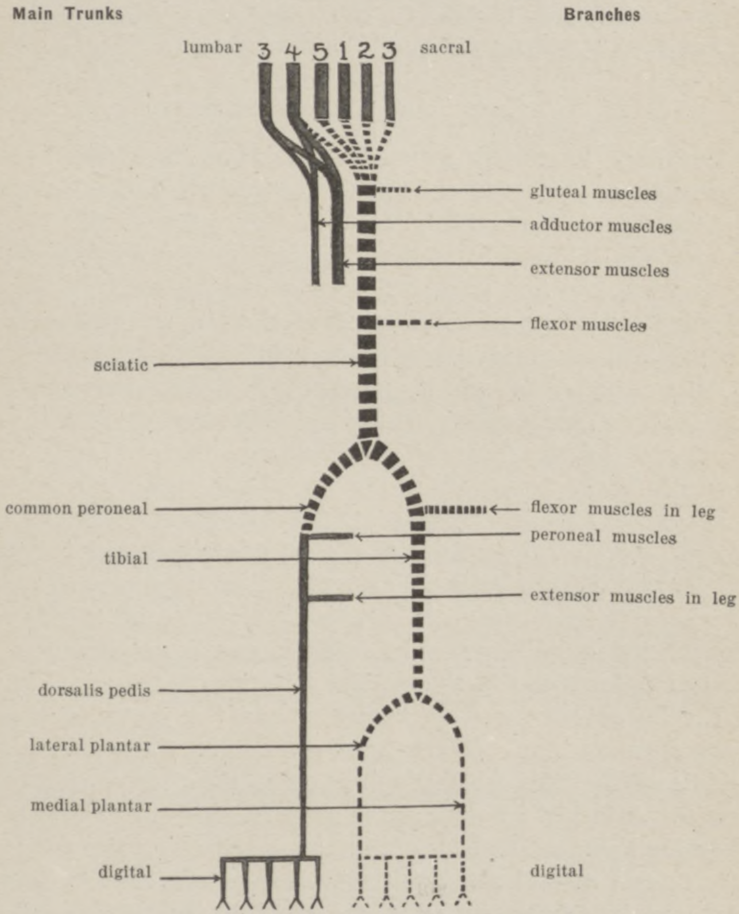

Fig. 36.—Diagram of Nerves of lower extremity. (Dotted lines are parts in posterior compartments.)

nerve turns around the upper end of the fibula and, after supplying the peroneal muscles, enters the anterior tibiofibular compartment. It then joins the anterior tibial artery in its further course, and receives corresponding names. The anterior tibial vessels in their original embryonic position followed the course of this nerve, but later develop a more direct route through the interosseous membrane. The larger **tibial nerve** supplies the muscles in the posterior tibiofibular compartment, and in its further course follows the posterior tibial artery. Its main divisions in the foot are known as the lateral and medial **plantar** nerves.

The vessels and nerves should be traced out.

Knee Joint (Articulatio Genu)

The knee joint is in general of the hinge type, but is modified inasmuch as near the end of the extension of the leg motion a limited but distinct internal rotation takes place. This rotation at the knee is referred to as the ''locking'' or ''screw-home'' device. Conversely, the first part of flexion of the leg starts with external rotation. The opposing surfaces of the femur and the tibia are arranged to accommodate this movement.

Anatomically the knee is essentially of the hinge type, that is, it has a strong capsular ligament connecting tibia and femur, strongly reinforced by the extensor muscle groups in front and the flexor group in back. Inasmuch as the lateral motion can not be strongly resisted by muscular action, we would expect to find thickened lateral and medial portions of the capsular ligament, the cord-like **fibular and tibial collateral ligaments.** Two ligaments run from the upper posterior surface of the tibia to between the condyles of the femur, which are known because they cross each other, as the **crucial ligaments** of the knee. The anterior crucial ligament acts as a check against excessive flexion, while the posterior crucial resists overextension. These ligaments prevent the tongue in the middle of the tibia from slipping out of the shallow groove of the femur. Attached by their outer circumference to the inside of the capsular ligament and to midline bony points on the tibia are the **lateral and medial menisci** (meniscus = crescent) (O.T. semilunar cartilages). These menisci taper towards the center and have a large central opening. These interarticular fibrocartilages keep the bones riding steadier, but still the joint may functionate fairly well after their surgical removal. The synovial membrane extends for several inches up under the extensor tendon, consequently increased amount of fluid can readily be seen to bulge out on both sides of the tendon. The patella may be floated away from its contact with the femur by increased joint fluids. On account of its exposed position, the reaction to injury or disease can be especially well followed in this joint, that is the accumulation of blood, pus or extra amounts of synovial fluid. The continuation of the quadriceps extensor tendon from the inferior surface of the patella to the tibial tuberosity is known as the ligamentum patellæ.

During about the last fifteen degrees of extension there is a slight rotation internally of the leg on the thigh, or if the leg is held firm, of external rotation of the thigh on the knee. The **popliteus muscle** arises from the lateral side of the lateral condyle of the femur and inserts into the upper half of the posterior surface of the tibia. This muscle may cause internal rotation of the leg or external rotation of the thigh, and is therefore an important factor in locking the knee.

Pieces of the menisci altered by disease occasionally become detached, roll up into balls and lie as foreign bodies in the joint. They produce symptoms by becoming caught suddenly between the opposing bone surfaces and wedging them apart. This is naturally associated with excruciating pain, is followed by increased joint fluid and what is popularly known as the symptoms of sprain. These bodies should be removed through surgical intervention.

The exterior of the capsular ligament should be cleared and examined with the aid of moving the bones. Then the front of the joint may be opened by carrying an incision down on each side of the quadriceps tendon. Finally the crucial ligaments and the remainder of the capsular ligament should be cut across and the opposing bony surfaces examined.

Ankle Joint (Articulatio Talocruralis)

The ankle is a typical hinge joint allowing for flexion and extension of the foot. The convex upper surface of the talus is held firmly between the malleoli of the tibia and fibula. As no muscles directly protect the sides of this joint, the side portions of the capsular ligament are thickened and may be called the **tibial** and **fibular collateral ligaments** of the ankle. The B. N. A. terms are too complicated for our purposes, inasmuch as they give eight separate names for the component parts of these ligaments. Both of these collateral ligaments are triangular in shape, spreading out at their attachment to the tarsal bones.

The distinction should be kept clearly in mind between the tibial and fibular collateral ligaments, which protect the joint, and the medial and lateral crural ligaments, which hold down the tendons. Falls on the foot in forced eversion produce a serious strain on the ligaments and bones, resulting in the characteristic Pott's fracture. This consists essentially in a tearing loose of the tibial collateral ligaments from the malleolus and a slanting fracture through the lower end of the fibula. When the everters of the foot, the peroneus longus and brevis, and the inverters, the tibialis anterior and posterior, act together, the net result is to hold the ankle joint steady.

The ankle joint should be dissected.

The range of motion between the tibia and fibula is distinctly limited, the poorly developed synovial cavities at both ends being rudimentary and often connecting with the knee and ankle joints respectively. The bones are held together by strong interosseous and capsular ligiments, especially powerful at the distal tibiofibular articulation (distal=furtherest from body).

These joints should be cleared, manipulated and dissected.

Tarsal Joints

The tarsal bones are held together by very strong **interosseous** and **plantar** ligaments and by weaker **dorsal ligaments.** The motion between the various bones is limited in extent and of a sliding character, but the sum total as brought out in eversion and inversion of the foot is large. The shape of the individual bones plus the great strength of the interosseous and plantar ligaments are obviously important factors in maintaining the arch of the foot. The deep fascia of the sole, running from the calcaneus to the ball of the foot, acts as a tie-beam and is another important factor.

But these ligaments and fascias would yield to continuous pressure unless supported by the muscles of the leg, especially the peroneus longus, tibialis posterior, and the flexor digitorum muscles. So important is the support of these muscles that most observers conceive the cause of the fallen arch to be the chronic putting of weight on the arch after these muscles are tired. The characteristic footprint shows the normal distribution of weight, the skin being thickened over the weight-bearing parts. The sagging arch is painful and in advanced cases the bony changes cause localized pressure, commonly resulting in painful corns. The destruction of the arch causes a loss of spring in walking. The treatment of fallen arches consists essentially in strengthening the muscles, plus a properly fitting support under the instep when the muscles are unavoidably to be submitted to undue strain. The body compensates for the raised heel of modern civilized man's shoeware so that removal of the heel from the shoe may actually cause pain. No reasonable anatomic ground for this custom is apparent.

The dorsal and interosseous ligaments should be cut, locating the joint interspaces by manipulation of the various bones. The bones will be held together and the arch maintained against considerable pressure by the very strong plantar ligaments. The tarsus contains a number of separate synovial cavities.

Other Joints

The **tarsometatarsal joint,** as in the hand analogy, allows but a limited range of motion being firmly held by dorsal, interosseous and plantar ligaments. This joint line is irregular, the second metatarsal being set in deeply between the first and third cuneiforms. The **metatarsal phalangeal joint** allows free flexion and extension, and slight abduction and adduction. It is a shallow ball and socket type of joint. The **interphalangeal** joint of both sets are of the typical hinge type, the opposing surfaces having a slight tongue and groove arrangement.

These joints should be dissected.

CHAPTER X

THE ABDOMEN

PERINEUM

The inferior wall of the abdominal cavity is known as the perineum. The perineum stretches across the inferior aperture of the lesser pelvis, often referred to in the female on account of the course of the child during the birth process as the outlet of the true pelvis. The bony landmarks of the perineum are: the crest of the pubic bones in front, the ischial tubers at the side, and the tip of the coccyx behind, outlining a somewhat diamond-shaped space. The rami of the pubis and ischium connect the tubers of the ischium with the body of the pubic bone, while the sacrotuberous ligaments connect the tubers of the ischium with the sacrum and coccyx. This region is divided as a matter of convenience by an imaginary line between the opposed tubers of the ischium into an **anal** and a **urogenital** subdivision. The anus is the terminus of the intestinal tract, while the front subdivision surrounds the terminations of the urinary and genital tracts.

Cloaca

At a very early stage of embryonic development the urogenital and intestinal tubes exist through the perineum via a common tube, known as the cloaca. The cloaca persists functionally throughout life in the lower vertebrates including the birds, but is not found normally in the fully developed animals of the higher mammal groups. The lower vertebrates have a partial separation of the cloaca into an anal and urogenital division, which simply becomes complete in all except the lowest orders of the mammalia group.

Pelvic Diaphragm (Diaphragma Pelvis)

The pelvic diaphragm forms practically a complete partition across the lower part of the lesser or true pelvis, the region below this diaphragm being the perineum, while the region above is the pelvic portion of the abdominal cavity. This diaphragm is made up by a thin muscle sheet, which is covered on each surface by fascias, known as the superior and inferior **fascias of the pelvic diaphragm.** The pair of muscles, known on account of their chief function as the **levator ani,** arise from the medial bony walls of the lesser pelvis along a straight line, which extends from the back of the symphysis pubis to the spine of the ischium. These muscles run medially, downward and backward, inserting into a median line tendon, which

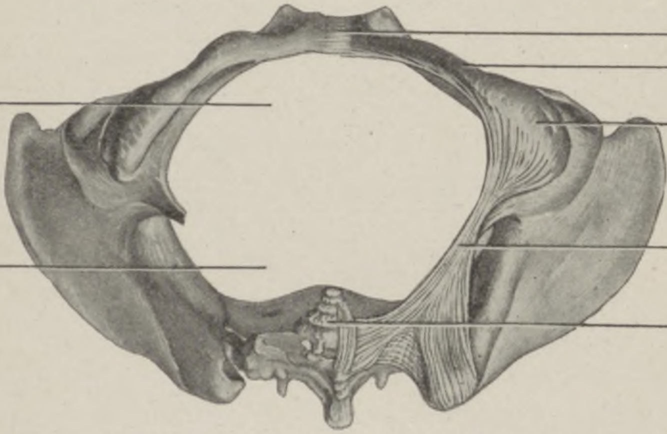

Fig. 37.—Bony-ligamentous boundaries of **Perineum.**

extends from the back of the symphysis pubis to the tip of the coccyx. This median line tendon of the levator ani muscles is perforated in both sexes by the anal tubes, while anteriorly it is perforated in the male by a combination urogenital tube, in the female by separate urinary and genital tubes. The part of the muscle sheet which arises from the spine of the ischium and inserts into the lateral margins of the coccyx is known as the coccygeus.

This pelvic diaphragm deserves especial attention as an anatomic boundary, and further, as will be detailed later, on account of its practical importance in the female.

Anal Region

The tube leading down from the rectum, that is, the straight terminal portion of the intestinal tract, to the surface is known as the anal part of the rectum. The area of junction of the mucous membrane with the skin is the anus, which in both sexes is located about the center of the region. The walls of the anal portion of the rectum are held in firm apposition physiologically by the contraction of the **internal sphincter ani muscle** (sphincter = encircle). This muscle is made up of involuntary muscle tissue, which is, however, to a certain extent at least, under the control of the will. This sphincter will later be reconsidered in connection with the other sphincter muscles of the gastrointestinal canal.

The skin over the anal region, being in a protected part, is rather thin, more especially so in between the folds of the buttocks. The fatty layer is especially liberal in amount and extends to the deep

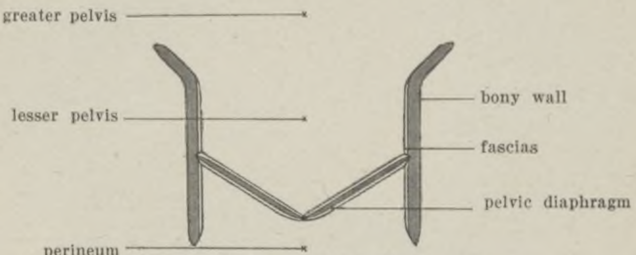

Fig. 38.—Diagram of Pelvic Diaphragm.

fascia of the levator muscle, technically the inferior fascia of the pelvic diaphragm. Towards the tubers of the ischium the fat is an inch and a quarter or more deep, and fills up a space loosely called the **ischiorectal fossa.** The lower part of the rectum, including its anal portion, is swung in the levator muscles, this fact being the justification for the name levator ani.

The ischiorectal fossa is of great practical importance because if a skin abscess works down into this ditch it may find either one of two methods of exit. The abscess commonly breaks through the skin and heals without trouble. If the skin is abnormally resistant, however, and is not incised early, the abscess may break through the levator muscle with its fascias and through into the anal portion of the rectum. Fecal material may then pass from the anal portion of the rectum into this ischiorectal fossa, the tortuous passageways may become blocked, and a new abscess result. This abscess may again break through into the anal portion of the rectum, but eventually it tends to work its way out through the skin, producing the condition known as fistula in ano. (fistula = diminutive wrong tract). These fistulæ, when neglected, tend to perpetuate themselves, and even to become worse. The probability of the formation of a fistula in ano is said to be greater if the patient has a chronic cough, for then the levator ani muscles are semicontinuously in action. These fistulæ can be cured by running a probe from the skin opening through the tract into the anal part of the rectum, dilating the sphincter ani muscles so as to minimize the number of muscle fibers cut, and dividing down to the probe. If the condition is an uncomplicated simple fistula in ano the wound tends to heal from the bottom up, the result being a complete cure. Fistulæ in this region due to disease of the neighboring bones must be carefully distinguished from the simple fistula in ano, as these fistulæ naturally differ materially both as to outlook and as to treatment.

The gluteus maximus muscle arises as low as the tip of the coccyx and therefore overlaps the sacrotuberous ligament and this anal region considerably. A small muscle runs forward from the coccyx, encircles the anus, and inserts into a central tendinous point of the perineum. This muscles is known as the **external sphincter ani,** which, being made up of striated muscle fibers, is under the control of the will. A pair of superficial transverse perinei muscles run from the ischial tubers to the central tendinous point of the perineum.

Vessels and Nerves

The **internal pudendal** arteries and veins and **pudendal nerves** run around the posterior border of the pelvic diaphragm in their course from the pelvic portion of the abdominal cavity to the perineum (pudor = shame). They course from the lesser pelvis through the greater sciatic foramen into the gluteal region, and, turning around the spine of the ischium, run through the lesser sciatic foramen into the perineum. Each pudendal artery, vein, and nerve runs forward just below the pelvic diaphragm and along the medial surface of the bony wall of the lesser pelvis, eventually terminating in the external genitalia. Superficial and deep branches from the femoral vessels in the upper part of the thigh carry an anastomosing blood supply to the external genitalia, known as the **external pudendal** vessels, but no nerves exist corresponding to these secondarily developed vessels. As the internal pudendal vessels and the pudendal nerves traverse the anal region they send off the inferior hemorrhoidal branches to the anal part of the rectum (hemorrhoids = running of blood).

Hemorrhoids, or popularly, piles, are dilated veins of the anal region, which will later be considered in their proper place, that is, in connection with the venous blood supply of the abdominal cavity.

The skin is to be dissected off the anal region, cutting through at its junction with the anal mucous membrane. After the subcutaneous fatty layer has been dissected out, the points noted in the description are readily to be made out.

Male Urogenital Region

Some fundamental considerations must first be taken up before the detail dissection of this combination urogenital region. In the first place the pelvic diaphragm, just as in the anal region, separates this part of the perineum from the pelvic portion of the abdominal cavity. The **testicles**, the essential male sexual glands, lie in a loose skin, fatty layer and fascial sac of the perineum, known as the **scrotum.** The testicles are developed in the abdominal cavity just below the kidneys and descend into the scrotum shortly before the birth of the child. The left testicle normally hangs somewhat lower than the right, which protects them against constant injury in walking. The testicles maintain their original blood, lymph, and nerve supply from the abdominal cavity, and consequently may be considered as belonging to that region and being only accidentally, as it were, in the perineum. The testicles will be considered in connection with the internal genitalia and also in connection with the course of the spermatic cord through the anterior abdominal wall.

Penis

The penis is made up of a root, that is the part attached to the bones and fascias of the urogenital subdivisions of the perineum, of a body, and of a glans. The combination urogenital tube, which traverses the penis from the root to the external meatus at the glans is known as the **urethra.** The essential structures of the body of the penis are three chambers, thickly walled by fibroelastic connective tissue and subdivided by numerous small septa, which are known as the **corpora cavernosa.** The spaces within the corpora cavernosa are continuous with the terminal branches of the internal pudendal arteries and veins, and, like the vessels, are lined by endothelium. An erection of the penis is produced by muscles, which contract down upon the outgoing veins, thus causing an increased amount of blood under high pressure in the cavernous spaces. The inferior of these cavernous bodies of the body of the penis, which is traversed by the

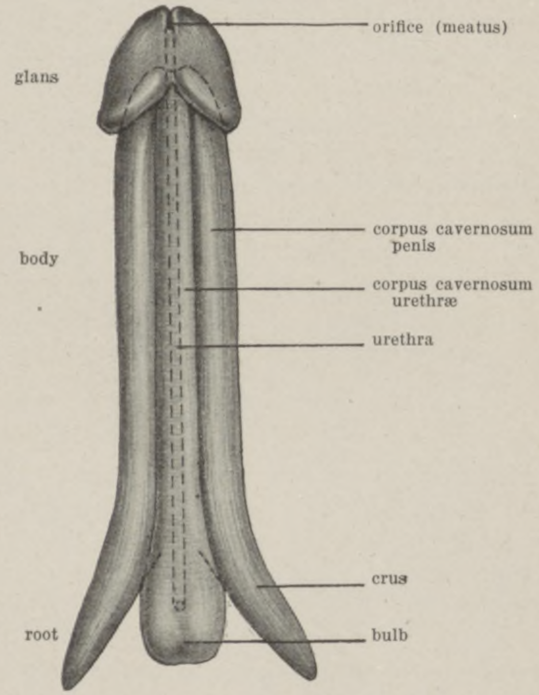

Fig 39.—Diagram of **Penis**, skin and subcutaneous fatty layer removed.

urethra, is known as the corpus cavernosum urethræ; the two superior cavernous bodies, incompletely separated from each other in the midline, are known as the corpora cavernosa penis. The erectile tissue of the glans penis is directly continuous with the corpus cavernosum urethræ, the two corpora cavernosa penis ending bluntly at the base of the glans. Towards the root of the penis each corpus cavernosum penis deviates laterally and, becoming known as the **crus** of the penis, attaches to the rami of the pubis and ischium. The corpus cavernosum urethræ runs straight back in the median line, widens out at the root, and becomes known as the **bulb** of the penis. The muscle which has the power of causing an erection and covers each crus of the penis is known as the ischiocavernosum; that covering the bulb, as the bulbocavernosum. The bulb of the penis attaches to the **inferior fascia of the urogenital diaphragm,** this attachment being the essential reason for the existence of this fascial membrane. This inferior fascia of the urogenital diaphragm attaches to the superior medial margins of the rami of the pubis and ischium, and blends at its posterior free border with the superior fascia of the urogenital diaphragm. On account of its shape, this fascia was formerly known as the triangular ligament. The muscles between the fascias of the urogenital diaphragm are known as the sphincter of the membranous urethra and as the deep transverse perineal muscles. The membranous urethra pierces this inferior fascia of the urogenital diaphragm about its middle and enters the bulb of the penis. Above the urogenital diaphragm, as previously noted, the pelvic diaphragm separates the urogenital subdivision of the perineum from the pelvic portion of the abdominal cavity.

Skin and Fatty Layer

The skin over the symphysis pubis region is of moderate thickness and well covered by hair. The skin over the scrotum is very thin, when relaxed, and has as a characteristic feature, involuntary muscle fibers, which, when contracted, cause the skin to be puckered up into folds. The skin over the penis is extremely delicate, the free fold over the glans penis being known as the prepuce, or, popularly, foreskin. The opposing surfaces of the glans penis and the foreskin are covered by a mucous membrane, which statement may be checked up macroscopically by the characteristic pink color of these surfaces.

The subcutaneous fatty layer is characterized by its extreme delicacy over the penis and scrotum. It contains the routine cutaneous vessels and nerves and a superficial venous system, the vessels being derived both from the external and internal pudendals. This blood and the corresponding lymph supply is of great practical importance in the understanding of infections or cancer of the glans penis.

Whenever the foreskin is so injured by accident or disease as not to turn back freely, thus preventing cleansing of the recess, surgical intervention is indicated. The foreskin should be split open on its dorsal, that is, its upper surface, or for cosmetic reasons a complete circumcision should be performed.

The skin and subcutaneous fatty layer should be dissected off.

Deep Fascia

The fairly strong deep fascia blends posteriorly with the base of the urogenital diaphragm, while laterally it is attached along the rami of the pubis and ischium, and to the sides of the body of the pubic bone up to the pubic crest. The part of this deep fascia enclosing the testicles and penis is thinner than the remainder.

When urine with its admixture of pus escapes from the urethra in back of a stricture, it undermines this deep fascia and eventually follows the line of least resistance onto the anterior abdominal wall (stricture = contracted scar). On account of the attachment of this deep fascia, urine does not spread back into the anal region or onto the thighs, but tends to mount higher and higher over the belly wall. The deep fascia, wherever undermined, should be incised to allow the escape of the foul, infected urine, while to prevent its reaccumulation an opening should be made in back of the stricture through the perineum into the urethra and bladder.

The suspensory and sling-like ligaments of the penis arise from the front surface of the pubic bones, giving support to the first part of the body of the penis.

Dissection.—The deep fascia should be split in the median line and turned back to its attachments. The testicles with their cords should be turned back over the front of the abdominal wall for later consideration. Blunt dissection with the handle of the knife will readily demonstrate the crura and bulb of the penis, covered by their musculature, and on their deep surface the inferior fascia of the urogenital diaphragm. On one side this fascia should be split anteroposteriorly in order to demonstrate the terminal branches of the pudendal arteries, veins and nerves entering the root of the penis. Then a series of cross-sections of the penis should be made to demonstrate its interior structure.

Female Anal Region

The anal region is practically identical in both sexes. Due to the fact that the lesser pelvis is relatively larger in the female than in the male on account of the requirements of childbirth, the distance between the tubers of the ischium is relatively greater.

Female Urogenital Region

The parts of the urogenital region which immediately surround the exits of the urinary and genital tubes is known as the **pudendum** or vulva. The two pairs of lips surrounding the urogenital cleft are known as the **labia** majora and minora pudendi. Each major labium is covered on its external surface by tough skin with a liberal supply of hair, while each minor labium folds inside and is covered practically throughout by mucous membrane. Into this urogenital cleft, technically the rima pudendi, the urethra empties about its midpoint, while just posteriorly lies the entrance to the vagina (vagina = narrow canal). The vaginal canal leads upwards and backwards to the uterus or womb, which lies in the pelvic portion of the abdominal cavity. Across the vestibule of the vagina lies a septum, known as the hymen or popularly maidenhead, which normally has an opening in its center. Occasionally this septum is not perforated, which clinically leads to symptoms due to the damming up of the menstrual or monthly flow in the upper vagina and uterus.

Urogenital Diaphragm

The urogenital diaphragm exists in the female, but, besides the opening for the urethra, possesses an extra opening for the vagina. Both the pelvic and urogenital diaphragms join into the side walls of the vagina. The vaginal portion of the levator muscles attach to the vagina about one inch inside of the pudendum, keeping above the urogenital diaphragm as would be anticipated.

Clitoris

The clitoris in the female is made up of erectile tissue, corresponding to the penis in the male, on a diminutive scale. Besides its materially smaller size, it is differentiated from the penis by the fact that the urethra does not traverse the clitoris. The body of the clitoris lies between the upper part of the labia majora, is attached by ligaments to the symphysis pubis region and hangs downward. The two **corpora cavernosa** of the clitoris separate at the root, become known as the crura, and attach to the rami of the pubis and ischium. Each crus clitoris is covered by an ischiocavernosum muscle. The clitoris is tipped by a miniature glans, which is covered by a free fold of mucous membrane, known as the prepuce. The

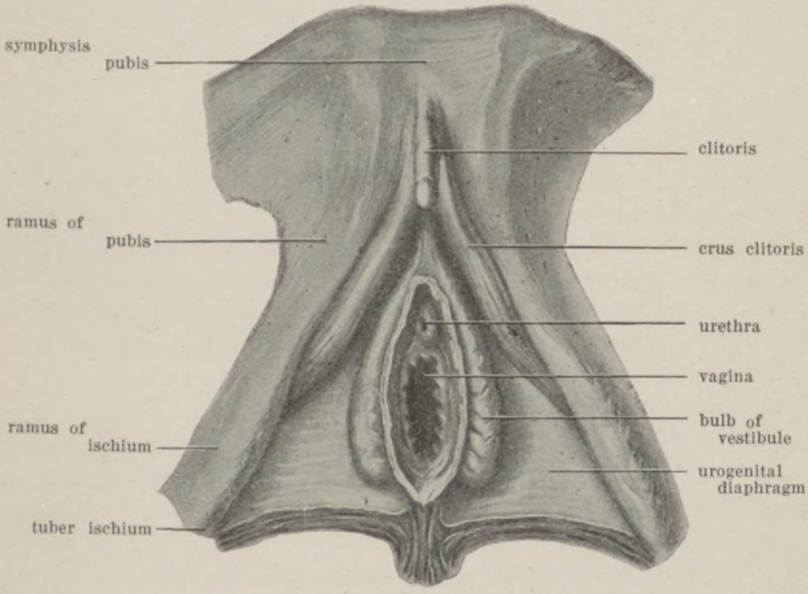

Fig. 40.—Female external genitalia, skin and subcutaneous fatty layer removed.

divided bulb is separated by the vagina into two halves, which are known on account of their position as the bulbs of the vestibule. These bulbs are attached to the under surface of the inferior fascia of the urogenital diaphragm and are covered by bulbocavernosum muscles. This separation of the two halves of the bulb is the original status also in the male, although the two halves normally fuse in the male, having the urethra between them. The median notch of the male bulb and the median scar under the corpus cavernosum urethræ are the permanent reminders of this developmental stage of the male.

The female urethra is a canal about one inch in length and is surrounded at the base of the bladder by a sphincter muscle.

Dissection.—The skin and then the subcutaneous fatty layer should be dissected off the urogenital region. Then the deep fascia should be split as near the median line as possible, and reflected back to the rami of the pubis and ischium and the base of the urogenital diaphragm. The two crura and the two vestibular bulbs of the clitoris should then be dissected and traced to their connections with the clitoris. By removing the inferior fascia of the urogenital diaphragm from one side the terminal branches of the internal pudendal artery, vein, and nerve, may be demonstrated.

Vaginorectal Space

The obstetricians often use the term perineum in the restricted sense of the region between the back of the vagina and the front of the rectum. This region is often torn in childbirth. The tear through the pelvic diaphragm and the posterior portion of the urogenital diaphragm is of major importance, and may occur with or without a tear through the skin. This accident is more apt to occur when the first child is born late in the woman's life, or following rapid or instrumental delivery. It is questionable how efficacious any of the efforts to prevent this accident really are, consequently a tear is not to be blamed on the attendant unless some ill-advised hastening of the labor process has been used. Immediate suture of the tear often results in fairly efficient repair, although never, to be sure, anatomically perfect. A severe tear of this type, or a minor tear when the muscles are weak, will allow the uterus and eventually the urinary bladder and rectum to sag down from their normal position in the pelvic portion of the abdominal cavity into the vagina. These parts may even, in neglected cases, appear outside through the pudendal rima or cleft. The descending uterus drags on its veins, partially obstructing them and becomes soggy with lymph and venous blood. The uterus, therefore, tends to increase in size and weight, which makes it bear down harder, resulting in a vicious circle. This vicious circle is best broken by sewing the pelvic and the urogenital diaphragms together in the midline. The round ligaments of the uterus are commonly shortened at the same time, which procedure helps temporarily to hold the uterus in position. This operation gives great relief to the sufferer, more especially in the severer traumatic cases, and is probably justly supposed to decrease the danger of cancer of the uterus.

Hermaphroditism

The term "hermaphrodite" (Hermes = a greek god; Aphrodite = a goddess) is applied to the class of human beings originally supposed to belong to both sexes. True hermaphroditism, that is, an individual having both functional ovaries and testicles, has never been proved to exist. The doubtful cases belong to the group with various genital malformations, for instance, the testicles remain in the abdominal cavity, the male urethra does not traverse the corpus cavernosum, or the clitoris so much overgrown as to simulate a penis. Many of these individuals have neither functional ovaries nor testicles, and are in reality sexless. But if functional sex glands are present, after puberty the secondary sexual characteristics ordinarily serve to determine their sex, that is, the voice, development of breasts, growth of beard, and the other lesser manly or womanly attributes.

THE ABDOMINAL WALL

Divisions

The area between the lower border of the ribs and the upper border of the bony pelvis is covered by various layers making up the abdominal wall. The tips of the lumbar spines are the bony landmarks in the posterior midline. Superiorly the lower border of the ribs with their cartilages and the xiphoid process are the surface bony landmarks separating the abdominal from the chest cavities. The crest of the ilium and the inguinal ligament separate the abdominal wall from the gluteal region and thigh, respectively, while nearer the middle line the crest of the pubis marks the division from the perineum.

As a matter of convenience in accurately locating internal organs it has become customary to subdivide the large abdominal cavity into a number of arbitrarily defined regions. The great number of systems proposed and more or less widely accepted is due to the fact that all systems have their serious limitations, as will be brought out in connection with the detailed consideration of the thoracic wall. In most of the proposed systems, however, the upper part of the belly cavity is known as the **epigastrium** and the lower part as the **hypogastrium** (gastrium = stomach, i. e., abdomen; epi = above; hypo = below). The area in the neighborhood of the umbilicus or navel is known as the **umbilical** region. The epigastric portions of the belly cavity under the ribs and costal cartilages is referred to in the B. N. A. system as the **hypochondrium** (chondrium = cartilage). In the use of these terms, however, it must always be borne in mind that their exact significance varies materially with the different systems.

Superficial Layers

The skin over the abdominal wall is moderately thick and over the less defensible posterior parts appreciably thicker. If the abdominal wall has been greatly distended during a prolonged period of time by a mass within the abdominal cavity, as, for example, by a large tumor, pregnancy or excessive stoutness, the dermis layer tends to tear open. These tears heal after the distension is relieved with the formation of shiny scars, known as striæ, which are ordinarily curved about the umbilicus as a center. Striæ are also to be found in other parts of the body wherever the skin has been unduly stretched, as in excessive stoutness, for example.

The subcutaneous fatty layer varies with the general stoutness, in stout individuals often becoming excessively thick. The depth of the navel gives an accurate estimate of the thickness of this layer, for fat never accumulates over this physiologic scar. The fatty layer contains the routine segmental cutaneous vessels and nerves, and a superficial venous system.

The deep fascia attaches along the iliac crest and the inguinal ligament of Poupart inferiorly, but does not attach to the pubic crest; hence the peculiarities of the lines of least resistance for escaped urine, as previously noted in connection with the male urogenital region. This rather weak deep fascia encases the abdominal muscles with their aponeuroses.

These layers should be dissected.

Muscles and Aponeuroses

The real strength of the abdominal wall depends upon the muscles with their aponeuroses.

Anterior Portion

On each side of the middle line lies the **rectus** abdominis muscle, which arises from the xiphoid process and from the costal cartilages of the fifth, sixth and seventh ribs. Its fibers, running approximately parallel, eventually insert into the crest of the pubis. This muscle is enclosed in the strong aponeurosis of the lateral abdominal muscles, which cross over and under the muscle in their course to the midline. The midline contains no muscle fibers, hence shows up white and is known as the **linea alba.** The umbilicus lies in the linea alba and somewhat nearer the pubis than the xiphoid. The blending of these aponeuroses at the lateral margin of the rectus muscles is white and is known as the **linea semilunaris.** Throughout the upper three-fourths the aponeurosis splits to enclose the rectus, but in the lower fourth of the area the whole aponeurosis goes in front of the muscle. A minor muscle, the pyrimidalis, arises from the pubic crest and inserts into the lower two inches of the linea alba, lying superficial to the rectus muscle.

The individual muscle fibers of the rectus do not traverse the whole distance, but after going three to four inches end in an irregular tendinous line, which is fastened to the rectus sheath (vagina musculi recti abdominis). The fibers end together, three or four transverse lines being found in the course from the costal cartilages to the pubis. Individual striated muscle fibers as a general rule are not more than three to four inches long, inserting into the fascias in the interior of the muscle. If a muscle belly is longer than four inches, other fibers start and continue their quota of the distance. Due to the fact that the individual fibers of this rectus muscle begin and stop together, this condition in this instance is macroscopically visible.

Lateral Portion

The lateral portion of the abdominal wall is made up of three muscle layers, which over the greater part of the region cross each other on deeper planes in three different directions. This matting arrangement obviously gives great strength relative to thickness. The outermost of these abdominal muscles is called the **external oblique,** the middle the **internal oblique,** and the innermost the **transversus.** Anteriorly the aponeuroses of these muscles come together at the linea semilunaris and are then continued, as just noted, over and under the rectus muscle to the linea alba. Posteriorly the deep fascia of these muscles blends with the posterior abdominal wall fascias and thus is connected up with the lumbar vertebræ. At the upper and lower areas of the wall the crossing of these muscles becomes less marked and eventually in certain areas the fibers parallel

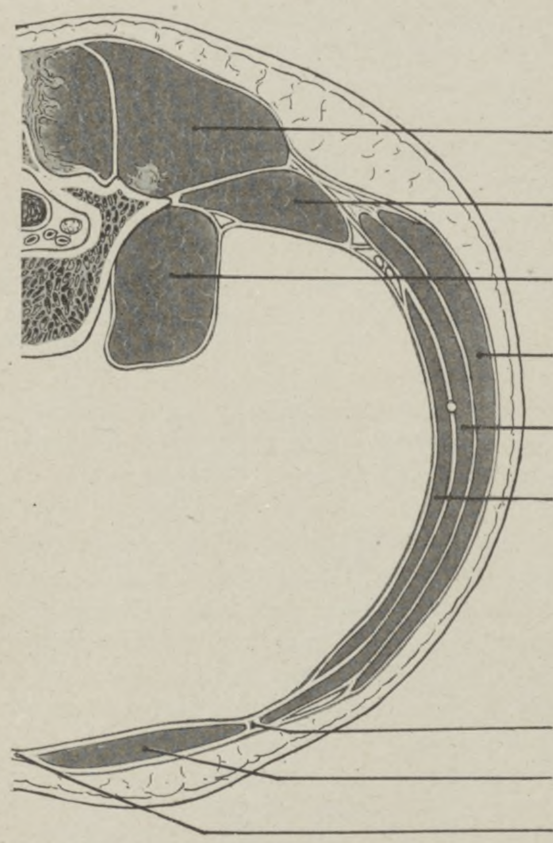

Fig. 41.—Muscles and Aponeuroses of abdominal wall, umbilical level.

each other, as will later be noted in detail. The external oblique follows a downward and medial direction, arising from the outer surface of the lower ribs and the lumbar fascias. The lowermost part of the external oblique aponeurosis is thickened to take part in the formation of the inguinal or Poupart's ligament. This inguinal ligament is a fusion of the lower part of the external oblique aponeurosis with the deep fascia of the thigh, reinforced by the external and internal deep fascias of the abdominal wall. The internal oblique arises from the lateral half of the inguinal ligament, from the greater part of the iliac crest, and from the lumbar fascia, running upward and medially to its aponeurosis. The transversus arises from the lower borders of the ribs, from the lumbar fascia, and from the crest of the ilium plus the inguinal ligament, running in the main transversely forward to its aponeurosis.

Posterior Portion

The extensor group of muscles of the vertebral column makes up the large fleshy mass on each side of the lumbar vertebræ, the muscles of the lateral and anterior portion of the abdominal wall being the opposing flexors. This **extensor vertebræ** muscle group is several inches broad and thick over the loin region and extends up the back, branching out into various columns, which eventually continue up through the cervical region to the skull. The relatively small muscle, which extends from the twelfth rib straight down to the posterior portion of the ilium is known as the quadratus lumborum. These muscles will be taken up in more detail in connection with the consideration of the vertebral column.

Nerve Supply

The segmental nerves of the lower six thoracic and first lumbar intervertebral foramina take a course just below their respective ribs, supplying the chest wall. These nerves then continue onto the abdominal wall, and, following the same downward and forward course, supply the lateral and anterior portions of the abdominal wall to the midline. The main trunks of these nerves lie deep under the muscles, but send off at appropriate intervals posterior, lateral, and anterior cutaneous branches. The posterior portion of the abdominal wall, that is, the extensor vertebræ muscle group area, is supplied by branches from the lumbar segmental nerves. The same segmental nerve which supplies the abdominal wall musculature also supplies the skin and the underlying organs. The clinical phenomenon that the overlying muscle is rigid during the painful affection of an intraabdominal organ is therefore explicable on this anatomic basis. If pain is referred to the back, it lies about at the point where the nerve makes its exit from the vertebral column.

Vessels

Developmentally a segmental artery and vein accompany each nerve to the midline in front, but during later development the rectus muscle takes its supply from what was originally the anastomosis. An **epigastric** artery is developed, which runs from the rib margin half way down the rectus muscle, and a **hypogastric** artery of the abdominal wall, which runs from just in back of the middle of the inguinal ligament to half way up the rectus. This hypogastric artery of the abdominal wall has become widely known, and even accepted in the B. N. A. revision, as the deep or **inferior epigastric artery**, but this is an obvious misnomer. The name epigastric instead of hypogastric was originally given to the artery by considering the body stretched out on its back, whereas anatomic nomenclature is generally and should invariably be governed by the upright standing position. The original segmental arteries carry the main supply in the adult for the lateral portions of the abdominal wall. The deep venous system accompanies the arteries, while, as elsewhere, an anastomosing superficial venous system lies in the subcutaneous fatty layer of the abdominal wall. If the main trunk veins inside the abdominal cavity become seriously obstructed, this superficial venous system may become enormously distended.

Deeper Layers

On the deep surface of the abdominal muscles and aponeuroses lies a layer of deep fascia, which is stronger in the lower part of the belly wall. This fascia is named according to its location, as transversus fascia, iliopsoas fascia, pelvic diaphragm fascia, and so forth. On the deep surface of this fascia lies a layer of areolar tissue, varying in amount with the general stoutness of the individual, known as the extraperitoneal fatty layer. The innermost lining of the belly wall is the **peritoneum**, a delicate membrane made up of endothelial cells (peri = around; toneum = stretch). This smooth surface of the inside of the belly wall and of the outside of the abdominal organs serves to reduce friction to a minimum.

The muscles and their aponeuroses, and the vessels and nerves should be cleared over one-half of the abdominal wall.

Hernia

A hernia or rupture is the protrusion or escape of an intra-abdominal organ through the abdominal wall, more commonly a part of the gut tube.

Inguinal Type.—The testicles in the male are developed in the neighborhood of the kidneys and, about three months before the end of the child's intrauterine life, make their escape through the

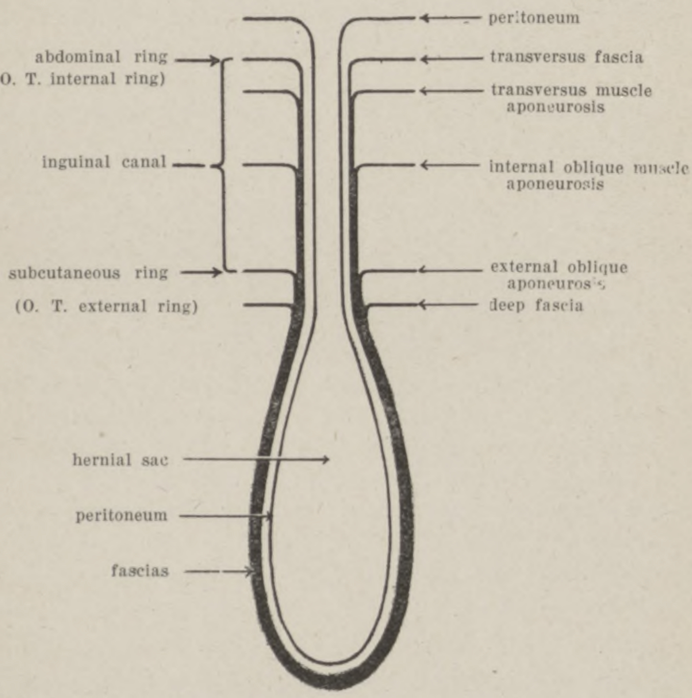

Fig. 42.—Diagram of Inguinal Hernia.

abdominal wall into the scrotum. The testicles do not break through the different layers of the abdominal wall, but theoretically at any rate carry a prolongation from each layer down into the scrotum. For a short period of time the peritoneum is directly continuous along the spermatic cord of the testicle into the scrotum, but normally this peritoneum soon disappears except where it forms a sac for the testicle itself. This double-layered serous sac of the testicle is known technically as the tunica vaginalis testis. If the peritoneal sac does not close, the individual has an open passageway into the scrotum, which is a congenital inguinal hernia. The spermatic cord passes through the peritoneum about the middle of, and one-quarter of an inch above, the inguinal ligament, then through the transversus fascia and muscle, then through the internal oblique muscle, and, finally, passing through the external oblique muscle, enters the scrotum. The space through which the spermatic cord passes is known as the **inguinal canal.** The openings in the muscles and fascias are normally only sufficiently large to allow the cord to pass through and are triangular in shape. When, however, intraabdominal structures work their way out along this avenue of lesser resistance, the openings spread and justify the names of the **abdominal and subcutaneous rings** of the inguinal canal, given to the openings in the transversus and external oblique muscles respectively. The internal oblique and transversus muscles arise from the lateral half of the inguinal ligament, but in this region deviate from their typical course by turning downward as a conjoint tendon into the crest of the pubic bone.

In repairing hernias of this type, the peritoneal sac is resected, and the internal oblique and transversus muscles and aponeuroses and the transverse fascia* are sewed down to the inguinal ligament. The hypogastric artery of the abdominal wall crosses this area deep to these muscles and just medially to the abdominal ring. Whereas the typical hernia of this region follows the spermatic cord and starts lateral to this vessel, some direct forms of hernia in weak old people break through medially to this hypogastric artery. Some muscle fibers and fascias derived from the internal oblique and transversus muscles form a sling about the testicle, known as the cremasteric muscle, which has the power of raising the testicle up towards the subcutaneous ring.

The inguinal is by all odds the commonest and therefore the most important of the hernias.

The lower part of the abdominal wall should be dissected on the

* Peculiarly the anatomic importance of the transversus fascia has been left out of account, so far as I could find out, in all herniotomy technics. By some methods and operators it was probably sewed, as it were, accidentally. A method of purposefully repairing this fascia has been reported by the author in an article entitled "Suggested Step in the Technic of Inguinal Herniotomy", Surg., Gynec. and Obst., March, 1919, pp. 329-331.

undisturbed side, with special reference to the spermatic cord and hernia.

Femoral Type.—Various structures continue from the abdominal cavity into the thigh under the inguinal ligament. But the only structures from inside of the fascias of the inner lining of the abdominal wall are the arteries and veins, the iliopsoas muscle and the

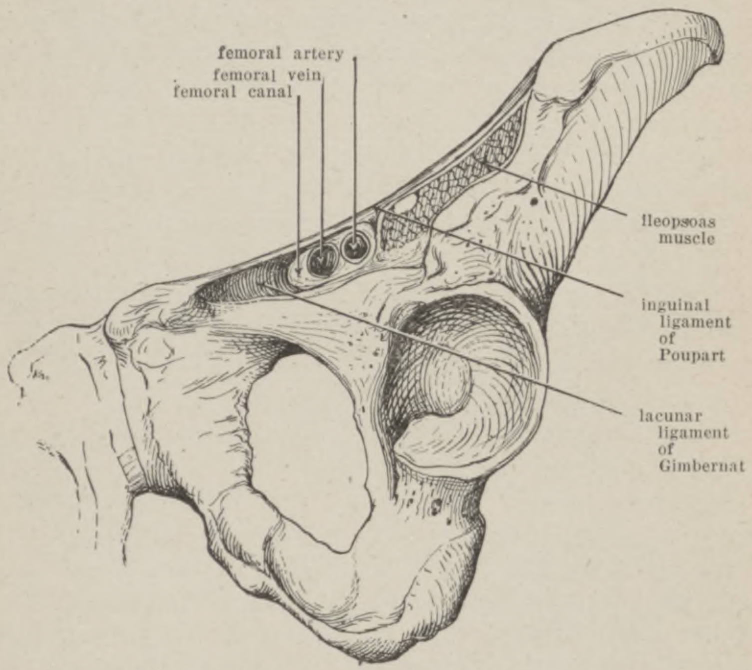

Fig. 43.—Femoral Canal and its relationship.

femoral nerve, for example, being outside of the inner fascias of the abdominal walls throughout. Vessels start from inside all of the fascias of the abdominal wall, hence it is possible to have a femoral, gluteal, sciatic, pudendal or obturator hernia along these respective vessels, but ruptures do not follow the nerves or muscles. The femoral vessels being the largest making their exit from inside the abdominal cavity, hernias in this position are relatively more frequent. Laterally to the femoral artery and vein, the transversus fascia in front and the iliopsoas fascia in back blend with the lower border of the external oblique aponeurosis to form the inguinal ligament. Over and under and along the sides of the femoral vessels, these fascias are continued for some distance into the thigh before they close down firmly on the vessels, forming the femoral sheath. The medial inch of the inguinal ligament is reinforced by a reflected band, which attaches to the superior pubic ramus and is known as the **lacunar ligament** of Gimbernat. Between the lateral margin of the lacunar ligament and the medial surface of the femoral vein is a small area not well supported. Through this small opening, which is known as the **femoral canal,** abdominal organs may under certain circumstances escape down under the fascia lata of the thigh. This is the femoral type of hernia, which tends to escape eventually through the saphenous opening of the deep fascia into the subcutaneous tissue of the thigh.

The space between the inguinal ligament and the hip bone should be dissected with special reference to femoral hernia.

Umbilical Type.—The umbilicus, or popularly, navel, is a puckered scar, its potential weakness causing it to be a rather frequent site for the occurrence of hernia.

Cause.*—The occurrence of five hernias, two inguinal, two femoral and one umbilical, in the same individual at one time is so common a clinical observation that the probability of a common underlying factor in all hernias is forced into our reckoning. This common factor is increased intraabdominal pressure, with, on the other hand, weakness of the abdominal musculature, or, in other words, a disproportion between the strength of the musculature and the amount of pressure it is called upon to withstand. Weak children with a chronic cough or chronic gaseous distension of the abdomen are to be relieved of hernia by correcting the underlying cause. Worn-out old people with chronic lung or intestinal disturbance often furnish the same picture in their second childhood. Any chronic obstruction to the outflow of urine, insofar as the patient makes use of general abdominal pressure to overcome the obstruction, may become a causative factor in the production of hernia. During the vigorous period of life, strong people, when chronically subjecting themselves to such overstrains as heavy lifting, may develop a hernia, more commonly of the inguinal type.

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* This argument has been presented in greater detail by the author in a paper entitled "The Cause and Prevention of Hernia," Jour. Am. Med. Assn., Sept. 8, 1917, lxix, 776-777.

It is only fair to state here that anatomists of a past generation have built up an elaborate theory of congenital developmental malformations as the cause of hernias. The arguments had considerable plausibility as far as infantile hernias are concerned, but never satisfactorily explained the primary occurrence of hernia in middle life and old age. Many of the collected facts are correct, but in the interpretation, causes and effects were confused. The open peritoneal tube leading through the belly wall is, according to the modern interpretation, not to be considered the cause of hernia, but to exist because there is chronic increased intraabdominal pressure. On account of the valve-like character of the inguinal canal, a single distention or strain, no matter how great, simply closes the walls tighter. Of course, if a rupture has started to descend, a single strain may cause a rapid increase in size, but this is an entirely different matter from really causing a rupture.

Hernias during the vigorous period of life should be corrected surgically, bearing in mind the probability of a lesser advanced condition on the opposite side. The results are excellent in the hands of competent surgeons, but the patient must be somewhat protected against a repetition of the original cause of the hernia. Excessively stout people of midlife are especially prone to develop the umbilical type of hernia. If their stoutness can be kept in bounds by exercise and diet, the results of surgical interference are good.

Complications.—Aside from their great inconvenience, hernias are important on account of the danger of strangulation of their contents, causing obstruction of the bowel. Small hernias with tight walls are more dangerous in this respect than medium-sized hernias with their larger rings. Early imprisonment or, technically, incarceration of the intestines may be caused to work its way back into the belly by putting the patient to bed with the pelvis raised and the limb semiflexed in order to relax the ligaments. If this procedure does not yield relief within a short time, the case demands emergency surgical intervention.

Surgical Incisions Through Abdominal Wall

A surgical incision through the belly wall is generally known as a laparotomy, which term originally meant an incision to remove stones. If a long incision in the belly wall is necessary, the middle line should be chosen, because no nerves and only anastomosing vessels cross this area. This rule is not so important in the upper half of the belly on account of the lesser danger of hernia, due to the fact that in upright positions of man, pressure in this region is not so great. Transverse incisions across the upper half of the abdomen have recently received clinical indorsement, the claim being that these incisions reduce the liability to postoperative hernia. Insofar as this incision preserves the nerves and splits rather than cuts across the main bundles of the aponeurosis, this innovation rests on a firm anatomic foundation. Over the lateral portions of the abdominal wall the muscle-splitting incisions are to be highly commended on account of the preservation of muscles, aponeuroses, and nerves, even in drainage cases minimizing the liability to hernia. The incision along the lateral border of the extensor vertebræ muscle group, if the twelfth thoracic and first lumbar nerves are cut, is often followed later by a hernia in the inguinal region. If infection of a wound is associated with sloughing of the aponeuroses and fascias, a type of postoperative hernia develops which is often very difficult to repair.

Superior Abdominal Wall

The diaphragm muscle with its aponeurosis and fascia forms the superior wall of the abdominal cavity and at the same time the inferior wall of the chest. It is attached around the inner surface of the lower rib margins and runs to a central aponeurosis, doming well up under the ribs. Hernias, following injuries or developmental malformations, may work through the diaphragm into the chest cavity. As a matter of dissection convenience, the further details in regard to the diaphragm will be taken up in connection with the chest considerations.

THE GASTROINTESTINAL TRACT

Peritoneal Cavity (Cavum Peritonæi)

The peritoneal cavity is a closed serous sac, lined as such sacs in other parts of the body by a single layer of endothelial cells. In the strict sense of the word there is no such thing as a peritoneal cavity for the vacuum draws the peritoneal surfaces of the abdominal organs into contact. If the vacuum is destroyed by opening the belly, or the peritoneal surfaces are forced apart by the presence of a fluid or gas, then of course a cavity exists. The peritoneum itself is a very delicate membrane, but, if taken up together with its extraperitoneal fatty and fascial layers, has considerable strength. The uterine tubes in the female carry the ovum from inside of the peritoneal cavity into the uterus, but air can not normally enter into the cavity via this route.

Organs inside the belly cavity are classified as **intra-** in contradistinction to **extraperitoneal.** Developmentally at an early stage all abdominal organs are extraperitoneal, but many gradually become intraperitoneal as illustrated in Fig. 44. No organ ever becomes entirely surrounded by peritoneum, but when the great bulk of an organ is covered by peritoneum it is considered an intraperitoneal

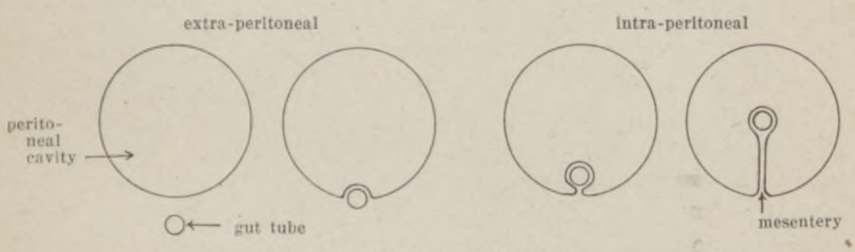


Fig. 44.—Peritoneal relationships.

structure. The use of the terms subperitoneal or retroperitoneal instead of extraperitoneal should be discouraged, inasmuch as these terms vary with the direction of approach, whereas extra has an unchanging significance.

It is worthy of special emphasis that fascial layers cover all organs of the abdominal cavity, forming compartments to hold them in place. Even though the peritoneal and fascial layer are intimately blended, the anatomic and functional distinction between these two layers should be kept clear, as failure to make this distinction has been a great source of confusion. A double fold of peritoneum and fascia, containing the vessels, nerves, and fatty tissue, leading to a part of the intestinal tract is known as a **mesentery** (mes = middle; entery = intestinal). Such parts of the intestinal tract as have a mesentery are movable, whereas those parts that lack a mesentery are fixed. The same type of structure with the distinction that it leads to the stomach is known as an **omentum,** or apron. Bands of white fibrous tissue, which hold the other abdominal organs in position, are known as **ligaments.** For convenience of description, the layer of peritoneum covering the various organs is known as the **visceral,** or organ, **layer,** whereas that lining the abdominal walls is known as the **parietal,** or wall, layer.

Contents of Abdomen

Developmentally the simplest type of abdominal cavity content is a straight extraperitoneal gut tube. As development proceeds, the tube lengthens, becomes coiled up, partly intraperitoneal and partly extraperitoneal, and becomes later differentiated into functionally different subdivisions. Thus we have the development of a **stomach,** the receptacle for and preliminary digester of food, of a **small,** or thin **intestine,** the main digestive segment, and of a **large,** or thick, **intestine,** which completes the absorption of digestible material, and also acts as a temporary reservoir for waste material. Special glands grow out from the first part of the small intestine, the **liver** and the **pancreas,** which specialize on the formation of digestive juices for the rest of the small intestine. The **kidneys,** which throw out of the body certain types of waste products, remain extraperitoneal in contact with the twelfth rib and send down tubes to the urinary bladder in the pelvic portion of the abdomen. Various sexual glands and tubes are found more or less closely associated with the urinary organs. And, further, just as though for good measure, the abdomen contains some ductless glands, the **spleen** and the **suprarenals.**

Walls of Gastrointestinal Tract

The inner lining of the gastrointestinal tract, or popularly the stomach-gut tube, is a **mucosa** (tunica mucosa). This mucous membrane varies in the different subdivisions of the tract, as will later be taken up in detail. Outside of this mucosa lies a white fibrous tissue layer known as the **submucosa** (tela submucosa), which gives the strength to the walls. The use of this layer from the lower animals for catgut and for sausage coverings has been previously commented upon. Outside of the submucosa lie the **muscles** (tunica muscularis), arranged in at least two layers and directions, the circular and the longitudinal. Outside of these muscles, wherever the tube is covered by **peritoneum,** is a serous covering of endothelium (tunica serosa).

General Principles

The contraction or relaxation of the muscle layers makes a tremendous difference in the appearance of an otherwise perfectly normal wall. The muscles are usually found somewhere between full relaxation and contraction, but at times both extremes may be noted, the surgeon, for example, characteristically finding full relaxation of the intestinal walls above a blockade of the tract and complete contraction below. A perfectly normal wall is a dozen times or more as thick when fully contracted as when fully relaxed, which fact must always be borne in mind in the examination of a section of the wall. Another important factor in the thickness of the intestinal wall is the amount of blood and lymph supply, which increases materially during functional activity and as a reaction to various irritants. The small or thin intestine when its muscles are fully relaxed, has a diameter of about three inches, the large or thick intestine, of about five inches, whereas both may contract until smaller than the little finger. But beyond the limits noted they can not distend, for the white fibrous submucosa is fully stretched and any further increase must tear this layer. When fully stretched a sudden tap, even though slight, may result in the bursting of the fibrous submucosa layer. When fully distended, the serous covering is made up of a single layer of endothelial cells, the muscle and fascias appear extremely thin, and the mucous membrane is smooth without any folds. When contracted down, all the layers are thicker and the mucous membrane piles up in heavy folds. The mucous membrane folds in the upper part of the small intestine, known as plicæ circulares, run around the inner circumference of the tube. It is claimed that these folds do not entirely disappear even on the greatest distension, but this alleged exception to the general rule requires more positive proof than has as yet been brought forward before it can be absolutely accepted.

These general principles apply not only to the gastrointestinal tract, but also to the urinary and gall bladders, and to other similar structures.

Muscle Layers (Tunica Muscularis)

The stomach possesses muscle layers in three different planes and directions, the mechanics of which arrangement has been explained in connection with the lateral abdominal wall. Throughout the intestinal tract there are only two layers, a circular lying next to the submucosa, and a longitudinal lying outside of the circular layer. At the inlet and outlet of the stomach, of the small intestine, and of the large intestine, the circular fibers are increased in amount to form **sphincter muscles** (sphincter = encircle or bind). The longitudinal muscles are distributed uniformly over the small intestine, but over the large intestine the longitudinal muscle is gathered into three bands, spaced equidistant about the cross-section of the gut. The longitudinal muscle bands are distinctly shorter than the large intestine, and, therefore, produce a characteristic puckering or frilling of the walls. One of these bands is invariably hidden by the attachment of the mesentery to the intestinal coil, but the other two are readily to be made out, showing up best when the intestinal wall is distended. The large intestine, when fully distended, is materially larger in diameter than the small intestine, but on account of varying degrees of distension, this is no real guide. The presence of the three longitudinal bands with their resultant puckering is the essential external feature distinguishing the large from the small intestine. It is appropriate to note here that the large intestine has numerous fatty appendages (appendices epiploicæ), which hang free from its outer surface and are not found in connection with the small intestine.

Dissection.—After these preliminary considerations, the student should be in a position to appreciate what is found on opening the abdominal cavity. If not already completed, an incision through the abdominal wall should be carried along the linea alba from the xiphoid process, turning slightly to the left at the umbilicus, and then down to the symphysis pubis. A transverse incision should be carried from the umbilicus to within a couple of inches of the lateral border of the extensor vertebræ muscle group. The four quadrants may then be turned back, exposing the interior of the belly cavity freely. The opposing parietal and visceral layers of peritoneum should be noted.

Examination of Abdominal Cavity

The large, solid liver should be noted in the epigastrium, chiefly in the right hypochondriac region, but commonly in dissecting room

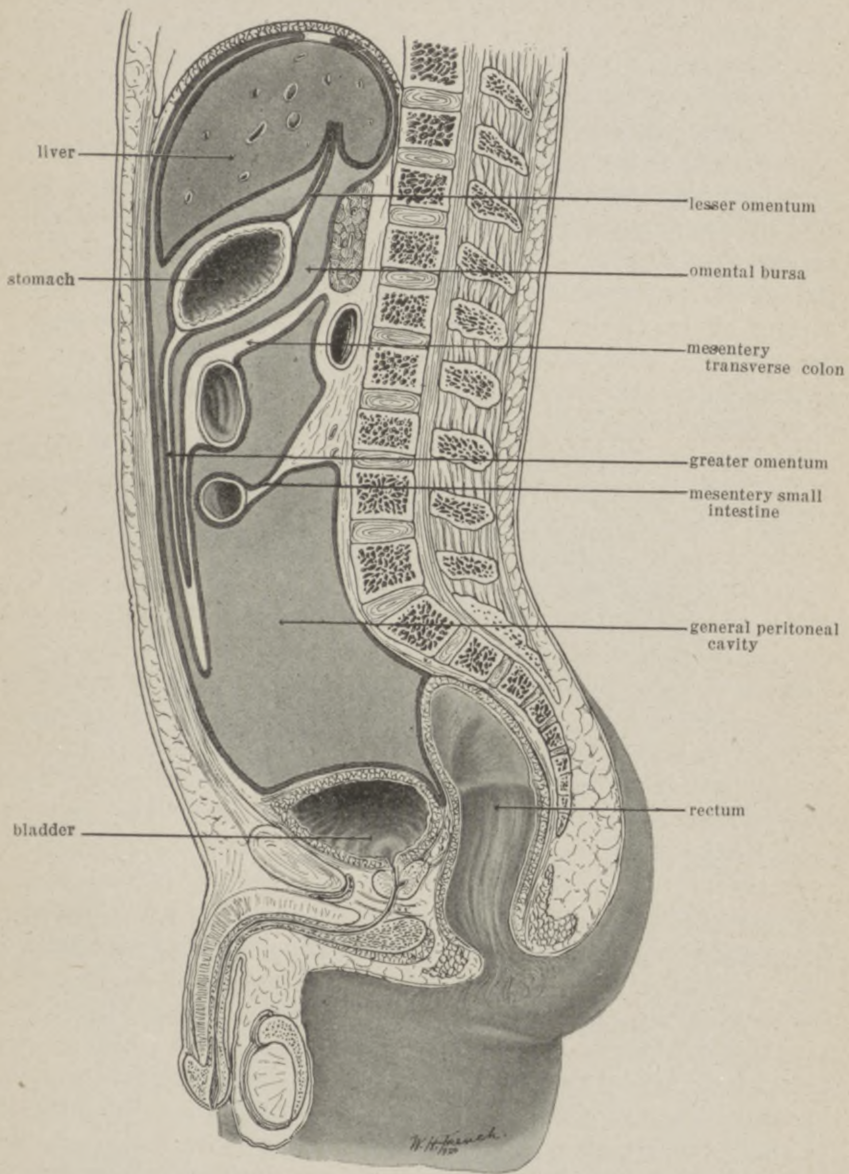


Fig. 45.—Arrangement of **Peritoneum**, diagrammatic median section.

bodies projecting down below the border of the ribs. If the spleen happens to be much enlarged, its rounded tip may be noted to project down from under the ribs in the left epigastrium. If it is not enlarged, the spleen can be palpated by following the lower surface of the diaphragm as a guide upwards and backwards, and then downwards. If the stomach is moderately distended, it will appear as a large bag stretched across the epigastrium, but if it is contracted down, may be withdrawn close up under the ribs and diaphragm. A large apron, the **great omentum,** hangs down from the lower margin of the stomach, and normally covers the anterior surface of the rest of the intestinal coils. This apron presumably has as one of its functions the protection of the intestines against chilling, but it also plays an important part in preventing the spread of peritoneal infections. If the lower end of this great omentum be picked up and, using gentle traction, be turned back over the chest wall, a coil of large intestine may be noted crossing in its posterior surface, which coil is known as the transverse colon. Then the intraperitoneal coils of small intestine should be traced from the point where they come out from under the transverse mesocolon at the left of the vertebral column to the point where they enter the large intestine, which point lies posterior to the midpoint of an imaginary line between the umbilicus and the anterior superior spine of the ilium on the right side. The mesentery should be examined by palpation and by transmitted light for blood vessels, nerves, lymphatic glands, and connective tissues. A coil of large intestine ascends towards the liver, goes across as the transverse colon, and descends on the left side into the pelvis, terminating in the rectum. The urinary bladder, even though empty, may be felt in the pelvic portion of the abdominal cavity, that is above the pelvic diaphragm and just in back of the symphysis pubis. The kidneys may be palpated on each side of the vertebral column, being extraperitoneal organs on a level with the twelfth ribs. If more than one body is being dissected, advantage should be taken of the opportunity to examine all specimens, on account of varying degrees of distention of the parts of the gastrointestinal tract. Unless the coils of large intestine are distended, it is often difficult in a dissecting room specimen to make out the longitudinal muscle bands, but in a fresh body these bands are readily to be made out.

Arrangement of the Peritoneum

At this stage of the discussion it is well to note the reflexions of the peritoneum. To trace first a vertical median line course, start on the front surface of the great omentum, which hangs down from the lower margin of the stomach, then comes in order the stomach, the lesser omentum over the liver to the diaphragm, along the diaphragm to the anterior abdominal wall, along this wall into the pelvis, crossing over the bladder, the uterus in the female, and over the rectum, up the posterior abdominal wall to the root of the

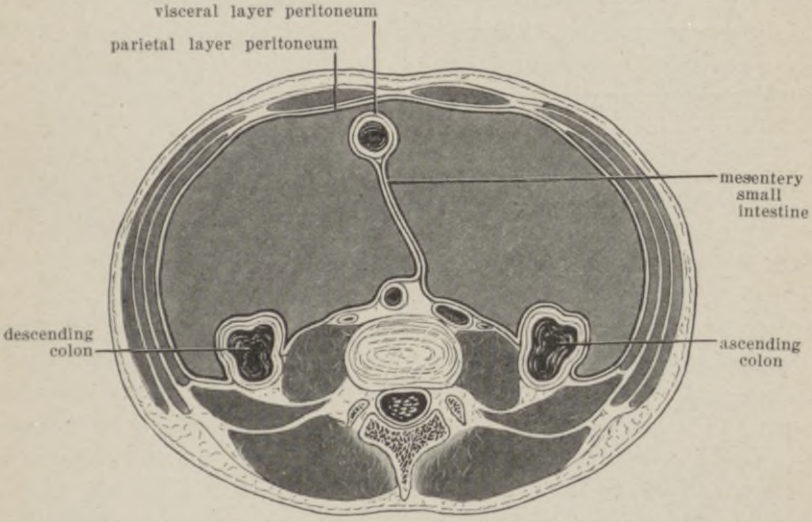


Fig. 46.—Arrangement of **Peritoneum**, diagrammatic transverse section.

mesentery of the small intestine, over the intestinal loop, and back again to the posterior wall; then down the transverse mesocolon on the posterior surface of the great omentum to the starting point. Between the anterior omental fold with the stomach and the posterior omental fold with the transverse colon lies the **omental bursa**, formerly called the lesser peritoneal sac. This subdivision of the peritoneal cavity has very thin walls, and therefore only minor practical importance. The omental bursa is continuous with the general peritoneal cavity through the **epiploic foramen** of Winslow, on the right side posterior to the gastrohepatic or lesser omentum (hepatic = liver).

A horizontal section would be from the umbilicus around the belly wall, across the large intestine, over the mesentery and coil of small intestine, across the opposite loop of the large intestine, and back along the belly wall to the starting point.

Practical

The opposing surfaces of the peritoneum under normal conditions move past each other freely and without pain, while in inflammation they tend to adhere to each other and to cause pain on movement. Peritonitis is now recognized to be a secondary disease, more commonly secondary to some diseased condition of the abdominal organs by direct spread (itis = inflammation of). The more common causes are appendicitis, inflammation of the uterine tubes, gall bladder infections, and perforations of the gastrointestinal tract.

Stomach (Ventriculus or Gaster)

The stomach is a muscularly walled sac, in contracted condition containing little inside space, while in an averagely relaxed condition it may contain from two to three pints. A gallon or even considerably more may be contained in a normal stomach, however, before the submucosa becomes stretched to its capacity. The upper opening, known as the **cardia** because it is nearest the heart, is fixed to the end of the gullet at the diaphragm. The lower opening, known as the **pylorus**, or gatekeeper, is somewhat movable between its omenta. Sphincter muscles are found both at the cardia and the pylorus, which muscles normally retain the food until the hydrochloric acid-pepsin digestion has changed the food into a thin gruel consistency. The stomach has a **lesser,** or superior, **curvature** and a much longer, **greater,** or inferior, **curvature,** and in the adult an anterior and posterior surface. During early development the stomach is in a more up and down position, its anterior surface being then the left lateral whereas its posterior is the right lateral, as the nerve supply to be considered later demonstrates. The adult stomach lies transversely, with the pylorus relatively fixed to the right of the median line about opposite the second lumbar vertebra.

Practical

Many general abnormal conditions of the body, having nothing directly to do with the gastrointestinal tract, may cause the stomach symptom of nausea, eventually vomiting. Stomach symptoms due to disturbances of the stomach itself are to be distinguished from the foregoing owing to the fact that they bear a definite relation to the ingestion and character of the food. Diseases of the liver ducts and the appendix also bear a relationship to the ingestion of food, and must be carefully excluded through time factors, pain localizations, and other individualizing symptoms before a diagnosis of intrinsic stomach trouble is permissible.

Chronic hyperexcitability of the inlet or outlet of the stomach may eventually cause an overgrowth of the cardiac or pyloric

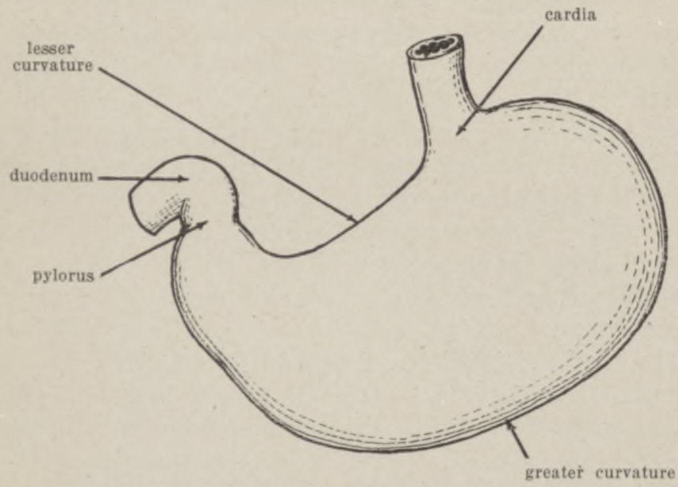


Fig. 47.—Stomach (ventriculus).

sphincter musculature. Many forms of chronic abuse of the stomach result in an excessive secretion of acid and eventually if the abuse is kept up this disturbance may be followed by a secondary decrease in acidity. An ulcer in the mucosa of the stomach or first part of the small intestine is a common accompaniment or perhaps sequel of this hyperacidity. The danger of hemorrhage from these ulcers or of perforations through the submucosa into the peritoneal cavity is said to be increased by gastric distention. The passing of a stomach tube often drains out great quantities of fluid with a minimum of disturbance, even though the patient has apparently emptied the stomach by vomiting. Modern x-ray work has demonstrated that the stomach musculature under an ulcer remains in a state of spasmodic contraction, as would be expected. Cancer of the stomach is considered to be a sequel to chronic ulcer by competent men, who have had large opportunity to study the subject from operative specimens. Cancers which involve the pylorus tend to cause obstructive symptoms, but cancer of other parts of the stomach may be palpable through the abdominal wall before giving rise to alarming disturbance.

Small or Thin Intestine (Intestinum Tenue)

The first part of the small intestine is known as the **duodenum** on account of the fact that it is about twelve inches long (duo = two; denum = ten). The first three inches are somewhat movable with the pylorus, but from this point, where the common ducts of the liver and pancreas enter, the remainder of the duodenum is extraperitoneal and firmly fixed across the vertebral column.

The remainder of the small intestine when freed from the mesentery and stretched out is approximately twenty-two feet in length, whereas the root of the mesenteric attachment across the vertebral column is only about six inches long. The small intestine as a matter of convenience is divided into approximately a first half, or **jejunum,** and a second portion, or **ileum** (jejunum = empty; ileum = twisted). The duodenojejunal junction is fixed to the left of the vertebral column, while the ileum—large intestinal junction is fixed in the lower part of the right lateral abdominal region. The small intestine, except for the duodenum, is intraperitoneal and freely movable on its long mesentery. The normal mesentery allows parts of the small intestinal coils to follow down into hernial sacs without being drawn taut, and with the belly opened permits the coils to be lifted out freely.

Practical

Cancers are so extremely rare in the small intestine that the clinical importance of this form of contracting stricture is practically nil. The common causes of anatomic obstruction of the small intestine are due to extrinsic factors, such as constriction in a hernial sac, or bands due to local or general, acute or chronic peritonitis. Clinically the higher up in the intestinal tract the obstruction occurs, the more severe are the symptoms. The resultant continuous vomiting of tremendous quantities of fluids will rapidly and certainly usher in a fatal termination, unless the water of the body is replaced through some other avenue: i. e., either per rectum or subcutaneously.

Large or Thick Intestine (Intestinum Crassum)

The large intestine is subdivided for convenience of description into a cecum, ascending colon, right colon flexure, transverse colon, left colon flexure, descending colon, sigmoid colon, and rectum. These parts are altogether about six feet long.

The **cecum** (cæcum) is the blind-ending portion of the large intes-

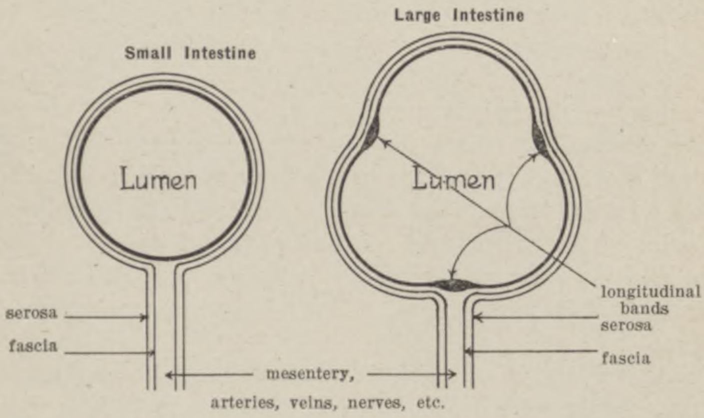


Fig. 48.—Diagrammatic cross section of Intestines.

tine below the entrance of the ileum (cæcum = blind). It normally has a short mesentery attaching it to the posterior wall in the upper part of the right lateral hypogastrium. The cecum is an extremely large important part of the large gut of the herbiverous animals and in the early stages of human development. Herbiverous animals must eat enormous quantities of their food in order to obtain sufficient nourishment and therefore require a large reservoir for absorption and waste.

The processus vermiformis or **appendix** is the vestigial remnant of this originally large cecum, which fails to reach its usual size in the human and in many carniverous animals. The processus vermiformis is a blind-ending tube, which connects at its open end with the cecum.

Whenever fecal material can not pass freely from the appendix into the cecum, the stagnating fecal material may putrefy and result in an attack of acute appendicitis. The formation of a circular stricture of the appendix, following previous inflammations, interferes with the normal drainage and predisposes to chronically recurring attacks.

The **ascending colon** is extraperitoneal and therefore fixed in its course up to the under surface of the liver, where after making the right colon bend, the large intestine continues as the transverse colon.

The **transverse colon** runs from the fixed right colon flexure across the front of the belly cavity to the fixed left colon flexure, but itself has a liberal mesentery and is freely movable. The mesentery of the transverse colon attaches across the vertebral column in the lower part of the epigastrium.

The **descending colon**, fixed to the left posterior wall, leads straight down to the left side of the brim of the pelvis.

The **sigmoid colon** takes a curve with a liberal mesentery over the brim of the pelvis, and continues beyond the third sacral vertebra into the rectum. The **rectum** rapidly loses its mesentery and especially in its lower part is firmly attached to the pelvic diaphragm.

The cecum, transverse colon, and sigmoid colon are then normally the only freely movable portions of the large intestine. As a reaction to inflammatory processes these normally movable portions of the large intestine may become fixed, or on the other hand, as will be detailed later, the normally fixed portions of the large intestine may acquire an abnormal range of mobility.

Practical

Complete obstruction of the large intestine may be caused by external bands or by hernial ring compression, but cancer stricture is the more common cause. In advanced inoperable cancers the making of an artificial anus through the abdominal wall above the constriction gives most gratifying relief from the symptoms.

Vessels

The arterial supply of the gastrointestinal tract comes from three vessels, the celiac axis, the superior, and the inferior mesenteric, which arises in this sequence from the front of the abdominal aorta. The **celiac axis** is a short stem artery of the epigastrium, which almost immediately breaks up into three radiating branches. These are the branch to the lesser curvature of the stomach, the branch to the greater curvature of the stomach, which also supplies the pancreas and spleen, and the hepatic branch, which also sends branches to the pyloric end of the stomach and first part of the duodenum. The **superior mesenteric** arises about a half inch lower down than the celiac axis, and supplies the remainder of the small intestine and the first half or more of the large intestine. The **inferior mesenteric** arises about opposite the umbilicus and supplies the descending colon, sigmoid colon, and rectum. The branches of these vessels communicate with each other freely through very large anastomosing stems. The smaller veins correspond accurately to the arteries, but the large veins corresponding to the celiac axis, superior and inferior mesenteric arteries run together into a large vein, which empties its blood into the liver. This extraordinary condition, for we would expect these veins to empty directly into the vein corresponding to the aorta, will be considered in connection with the liver.

The lymphatic vessels as usual accompany the veins and run through lymphatic glands in the mesentery. The lymphatic vessels empty into a main reservoir, which will later be noted to be drained by a lymph duct, which follows the anterior surface of the vertebral column up to the base of the neck.

Nerves

Very large matted strands of sympathetic nerves follow the arteries and their branches to their terminations, receiving corresponding names. These nerves are not under the control of the will, but automatically regulate the blood supply, the movements, and some of the other activities of the gastrointestinal tract. They make the same segmental connections with the spinal cord as the nerves which control the abdominal wall; i. e., the last six thoracic and the first lumbar. Eventually the lower four lumbar, the sacral, and coccygeal segmental nerves control the lower portions of the abdominal cavity and its contents.

The very thick matted plexus around the origins of the celiac axis and superior mesenteric arteries was formerly known as the solar prevertebral plexus (solar = comparison to rays of sun). This large, matted plexus contains numerous ganglia, which are aggregations of the bodies of nerve cells held together by connective tissue. The lower six thoracic segmental nerves send processes down on each side of the aorta, known as the splanchnic nerves, which connect this plexus with the spinal cord. The branches from this and the other minor prevertebral plexuses are named according to the arteries they follow.

Another series of plexuses with ganglia can be located microscopically in the various organs. These are known as the visceral plexuses and are named according to their respective organs.

The main points in regard to the vessels and nerves should be worked out by dissection.

Practical

When a coil of gut is to be freed from adhesions and mobilized, it is obviously important to separate from the lateral side. For the vessels and nerves arising near the midline and running laterally, any attempt to separate between the gut and the midline seriously endangers the blood and nerve supply.

Dissection

The stomach, the small intestine, except the duodenum, and the large intestine are to be removed from the body for more detailed examination. The stomach should be cut across close to the diaphragm and the duodenum should be divided about one inch beyond the pylorus. If part of the gastrointestinal tract to be cut has much contents, as a matter of neatness it is advisable to tie cords around the intestinal tube and divide between them. The small intestine should be sectioned at the duodenojejunal junction and then the mesenteric attachment of the jejunum and ileum cut close to the coils. Then the large intestine should be similarly removed, starting at the cecum and continuing down to the rectum, which should be cut across.

By tearing off the peritoneal and longitudinal muscle coats it is usually possible to demonstrate the bundles of circular muscle fibers. The stomach, and sections of the small and large intestines should be laid open freely by a longitudinal cut in order to examine the mucosa, noting especially the exaggerated mucous folds wherever the gastrointestinal circular musculature is contracted. In a fresh coil of gut it is relatively easy to scrape the mucosa off the inner surface, and the peritoneum plus muscles off the other, thus demonstrating the submucosa. Unfortunately the mucosa in dissecting room bodies is usually poorly preserved, hence many of the things to be made out in a fresh specimen by the naked eye or by hand-glass magnification are not demonstrable. However, even if no fresh material is available, the attempt should be made to connect up the gross appearance of the mucosa with the microscopic findings, which will now be summarized.

Mucosa (Tunica Mucosa)

The mucosa of the gastrointestinal tract, being of the secretion and absorption type, is lined throughout by a simple columnar epithelium with goblet cells (see mucous membranes, p. 33). Throughout the entire gastrointestinal tract crypts extend down into the mucosa, which when viewed from the surface under hand-glass magnification appear as little round pits. This description unmodified describes the mucosa of the large intestine. The mucosa of the stomach is on the same general principle as that of the large intestine, with the addition of glands which secrete the gastric juices and pour it into the bottom of the crypts. The small intestine in the higher animals has no glands to pour out the digestive juices on the mucous membrane, the place of such glands being taken by the specialized glands, the liver and the pancreas. On the other hand large, irregular projections known as villi extend above the surface of the small intestinal mucosa and serve to increase the surface.

Nodules of lymphatic tissue may be found microscopically in all mucous membrane throughout life. Just like the lymphatic glands these nodules tend to increase in size and probably also in functional ability as a reaction to bacterial poisons. These nodules are clinically found to average larger in early youth, when the resistance to bacterial poisons is less developed, in those mucous membranes particularly exposed to bacterial infection, and in any mucosa subject to an acute or chronic infection. The lymphatic nodules in the gastrointestinal mucosa conform to these generalizations, being relatively large even in perfect health during infancy and early childhood throughout the whole gastrointestinal tract.

The stomach and the first half of the small intestine are protected by the gastric and biliary-pancreatic secretions, respectively, which normally keep bacterial growth down to a minimum, the lymphatic nodules in these areas being normally insignificant. The lower half

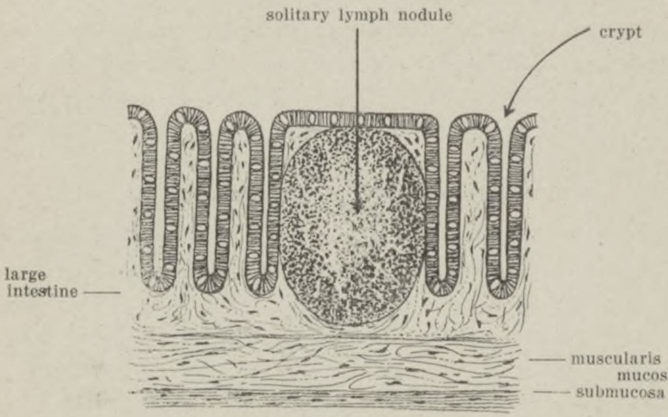


Fig. 49.

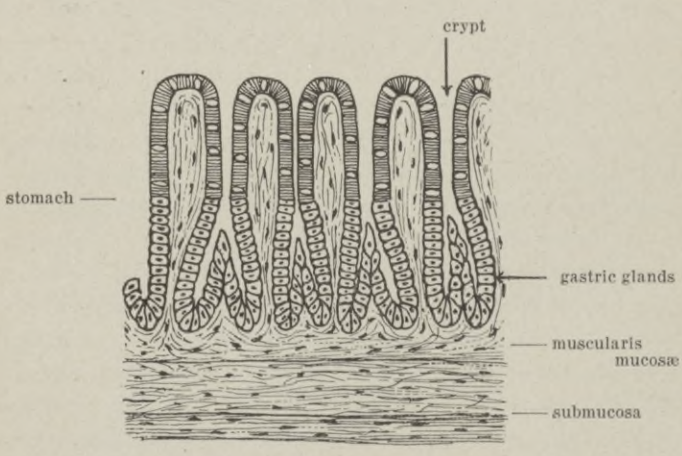


Fig. 50.

of the small intestine and the large intestine are normally full of bacterial life, and it is in this portion of the gastrointestinal tract that the lymphatic nodules are best developed. **Solitary lymph-nodules** (noduli lymphatica solitarii) can be found microscopically throughout the stomach and small intestine and much more abundantly throughout the large intestine. In addition to its solitary lymphnodules the small intestine has about thirty **aggregated lymphnodules** of Peyer, which are about equidistantly spaced and are invariably located opposite the mesenteric attachment. These thin plaques naturally vary in apparent size with the amount of distension of the intestinal coil, but average perhaps one-quarter times one and one-half inches.

Clinically these aggregations of lymphatic tissue become enlarged

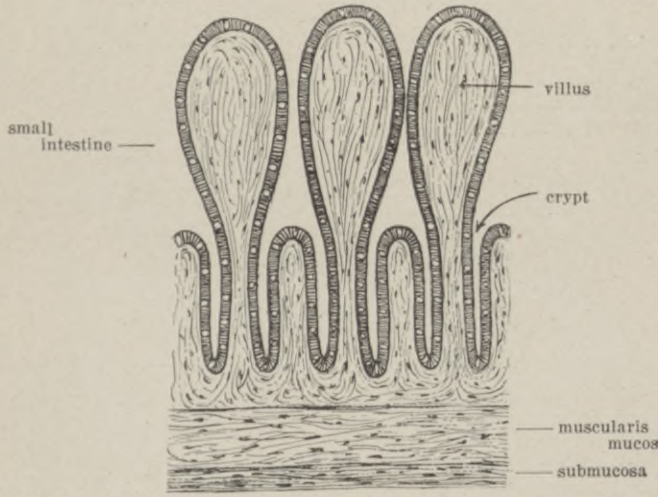


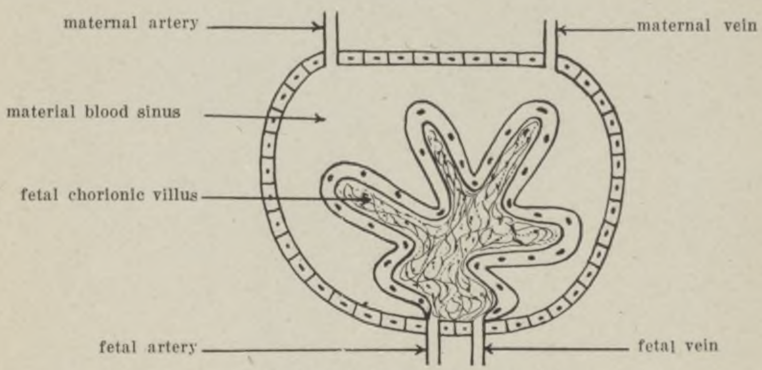
Fig. 51.

Figs. 49, 50, and 51.—Diagram of **Mucosa** of gastrointestinal tract (x 100).

as a reaction to any bacterial infection of the intestinal tract, the typical example being typhoid fever in which each solitary lymphnodule at the height of the attack becomes about split-pea size. If the infection persists or reaches great severity, the process may go on to ulcer formation of these areas, the pus eventually formed following the line of least resistance by breaking through the mucosa into the lumen of the intestinal tract. Normally these ulcers lie inside the submucosa, which forms their floor. If the submucosa becomes weakened, however, and an intestinal coil becomes greatly distended there is acute danger of a perforation through the intestinal wall into the peritoneal cavity.

Embryologic Blood Supply of Abdomen

In order to obtain a broad conception of the liver, it is necessary to consider first the embryologic blood supply of the belly cavity. The developing child while in the womb does not take supplies or throw off waste by means of its own organs, but effects these requirements of life by an intercharge between the embryonic or fetal and the maternal circulations. After two months of intrauterine development, the human embryo is about one inch long and becomes known as the **fetus** (fœtus). The circulatory system of the develop-



chorionic = full of capillary vessels
villus = shaggy, i. e., a projection

Fig. 52.—Diagram of **Placenta** (x 150).

ing fetus uses the child's own blood, which does not mix with the maternal blood, the red blood cells of these distinct circulations being separated by at least two layers of modified endothelial cells, as illustrated in diagram. Whereas theoretically we would expect the bloods of the fetus and mother to be separated by a layer of fetal and of maternal endothelial cells, the embryologic evidence acquired up to date makes it appear more probable that both these layers are of fetal origin. The organ in which this interchange takes place is known as the **placenta** (cake-shaped). The placenta is made up of a maternal and fetal part, and after birth, being no longer required, is expelled. It is, therefore, popularly known as the afterbirth. The cord connecting this placenta with the navel of the fetus contains as its essential constituents fetal vessels together with some connective tissue and an outer skin covering.

Vitelline and Allantoic Sacs and Ducts

Animals below the mammals do not have a placenta, which statement also applies to the human embryo in its earliest stages of development. The yolk of a developing bird's egg becomes surrounded by a vitelline sac, which connects by a duct via the navel with the intestinal tract of the developing chick. As development proceeds the yolk nourishment is absorbed into capillaries of the vitelline vessels and the extraabdominal portion of the vitelline sac becomes progressively smaller. Waste products are thrown out from the cloaca via an allantoic duct, which runs through the navel into an allantoic sac, the extraabdominal portion becoming progressively larger as development proceeds. Vessels incidentally grow out along the allantoic sac to the inner surface of the shell of the egg, taking care of the interchange of carbon dioxide and oxygen. Now the human embryo develops both vitelline and allantoic sacs and ducts, even though it probably never really uses either of them. A number of other similar facts will be noted later, all of which emphasize our anatomic relationship to the lower animals. If abnormally the vitelline duct persists in the fully developed human, it runs from the navel to the ileum about two feet above the ileocecal junction, and is known as the **diverticulum ilei** of Meckel. It may persist in part or *in toto*. The allantoic duct normally persists in the adult as the obliterated **urachus** running from the navel to the nearest medial point of the bladder. In case of obstruction to the urinary outflow via the normal route, this normally obliterated urachus may remain patent and allow the escape of urine via the navel.

Umbilical Arteries and Vein

Two umbilicial arteries carry the child's blood to the fetal portions of the placenta, while one umbilical vein carries the purified blood back. Veins, as previously noted, are not named according to the character of their contents, but according to the direction of flow, that is, whether towards or away from the heart. The umbilical arteries arise from the hypogastric arteries of the lesser pelvis and passing along the sides of the bladder converge at the umbilicus. The umbilical vein carries its blood towards the heart, but part of its blood runs through a second set of capillaries in the liver before returning to the heart. The bulk of the blood in the umbilical vein, when it reaches the inferior surface of the liver, short-circuits through the **ductus venosus** into the inferior vena cava, which empties into the heart. The umbilical arteries and the vein and the ductus venosus, having no function to perform after birth, become obliterated and remain as fibrous cords in the adult. The place at about the middle of the inferior surface of the liver where the umbilical vein and other structures enter or exit is known as the porta, or gate, of the liver.

Vena Porta

The veins returning from the gastrointestinal tract of the adult, the veins corresponding to the celiac axis, superior and inferior

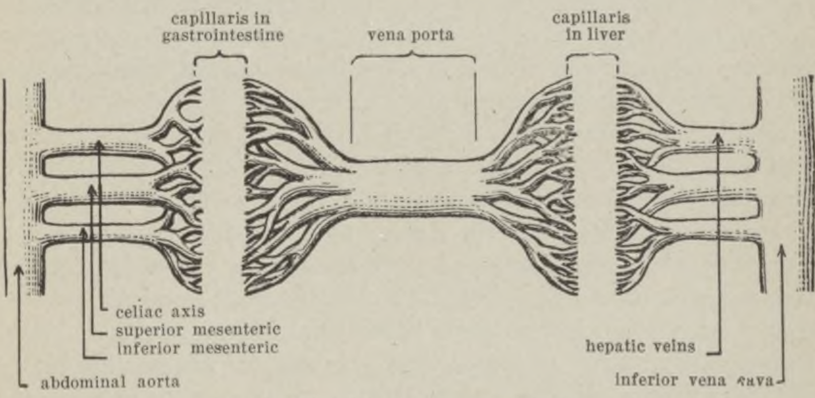


Fig. 53.—Diagram of Portal Vein circulation

mesenteric arteries, unite to form the vena porta. Now this vena porta sends its blood through this same system of capillaries in the liver as is used by part of the blood of the fetal umbilical vein. This is an extraordinary anatomic fact, which must have some functional necessity back of it. The working theory that one function of the liver is to protect the general circulation against any substances abnormally absorbed from the gastrointestinal tract has a sound anatomic basis. It is now a well-established fact of physiology that certain foodstuffs, notably the albumins, if injected subcutaneously without first undergoing digestion, cause profound disturbances of the body. The liver stores up certain foodstuffs as a reserve supply, and probably changes other absorbed products of digestion before they are allowed to enter the general circulation.

Liver (Hepar)

The liver is developed as an outgrowth from the duodenum, and as noted in connection with the mucosa of the small intestine, takes the place of digestive glands throughout this mucosa. It is a large solid organ, which fits up under the vault of the diaphragm and normally does not extend below the ribs except near the front midline. About nine-tenths of the liver lies to the right of the median line, filling up the whole right hypochondriac region, while only a thin tapering projection runs into the left hypochondrium. The normal position of the liver under the ribs gives constant protection to the organ, whereas when extending further down, the muscle protects only if contracted. The liver is firmly attached to the diaphragm by a circular crown ligament, with the right and left lateral portions extending to their respective sides. It is surrounded by peritoneum, except for the vessel and ligament entrances. The obliterated umbilical vein, also known as the round ligament of the liver, with its double fold of reflected peritoneum, divides the inferior surface of the liver into a right and left lobe, the right lobe being considerably the larger. The vertebral column causes a deep depression in the posterior surface of the liver.

The essential liver cells are translucent like the white of a fresh egg, the normal color of the organ being due to the rich supply of blood in capillary vessels plus the presence of bile. The normal consistency is rather soft on account of the relatively small proportion of connective tissue, the whole organ being surrounded by a rather weak fibrous coat plus peritoneum. Acute inflammations cause the liver to swell, whereas long continued chronic irritations lead to an increase of, and eventually a secondary contraction of, the fibrous tissue framework. This secondary contraction is known technically as cirrhosis or hardening of the liver.

Blood Supply

The liver has, as would be anticipated, an arterial and venous supply, which, however, take separate courses, and a collecting duct system. The vena porta, which collects the blood from the veins corresponding to the celiac axis, superior and inferior mesenteric arteries, is therefore the only unexpected feature in the anatomy of the liver. The vessels entering the inferior surface of the liver at the porta are the **vena porta** and the **hepatic artery,** a branch of the celiac axis. The vena porta carries venous blood back from the gastrointestinal tract, whereas the hepatic artery carries arterial

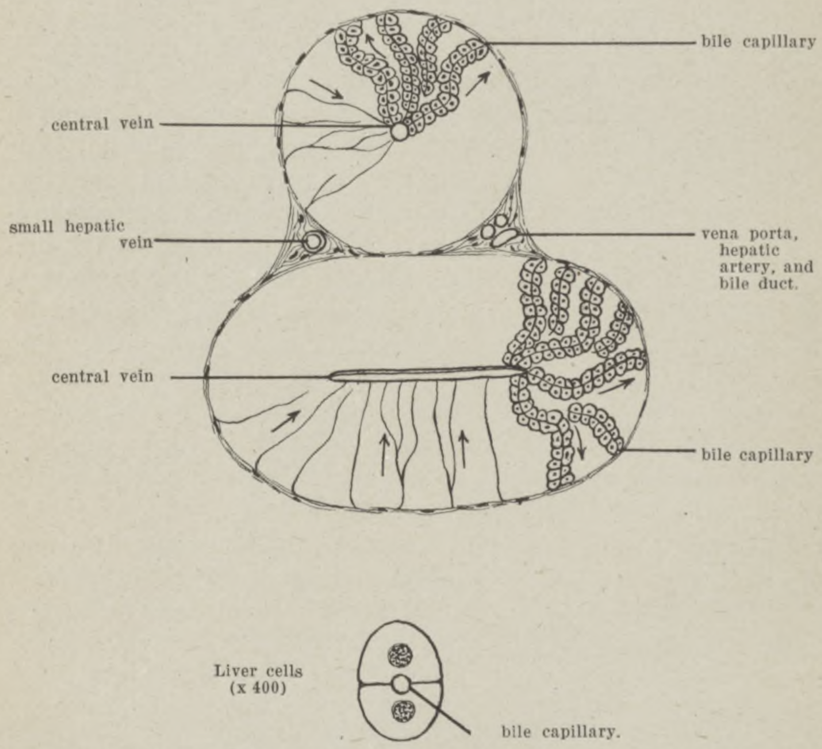


Fig. 54.—Lobules of **Liver**, diagrammatic (x 100).

blood for the care of the tissues. The right and left hepatic ducts, carrying the biliary secretions of the liver cells, leave the liver at the porta en route to the duodenum. This hepatic artery, vena porta, and bile duct, and their subdivisions, are held together by connective tissues, known as the fibrous capsule of Glisson. These three structures, as they traverse the liver in company, divide progressively into smaller and smaller subdivisions, but, on the other hand, the smaller branches become more and more numerous. The smallest subdivisions of the hepatic artery, vena porta and bile duct terminate at a lobule about the size of a pin-head, which lobule is itself a miniature of the whole liver. The bloods of the hepatic artery and vena porta traverse capillaries from the outer side of the lobule to a centrally placed vein. These central venules are non-collapsible spaces in the liver substance, which join with others to form the smaller **hepatic veins.** The large hepatic veins are constantly open tubes, which connect via a variable number of branches with the inferior vena cava as it passes along the posterior surface of the liver.

If the vena porta or its branches are semi-obstructed from any cause whatsoever, the anastomosing veins of the general circulation at the upper end of the stomach and the lower end of the rectum will become greatly distended. In the rectal mucosa these distended veins are called hemorrhoids on account of their tendency to bleed. Some of the specific factors causing hemorrhoids are obstruction of the portal circulation in the liver, chronic increased intraabdominal pressure, and various local disturbances to the return circulation of the rectal veins. If the vena porta or its capillaries in the liver become severely obstructed, lymph is secreted from the capillaries of the gastrointestinal tract faster than it can be carried off by the lymphatic vessels. This lymph then collects in the peritoneal cavity and commonly distends the belly wall to the point at which pressures and counterpressures are equalized. This collection of lymph in the peritoneal cavity is known technically as ascites.

Bile Passageways

Bile is secreted by the liver cells, which are arranged within the lobules in curving strands as illustrated in the diagram. Each of these strands is made up of a series of paired liver cells, which enclose a passageway, known as the smallest bile ducts. The smallest bile ducts empty into the larger interlobular ducts, these interlobular ducts empty into the hepatic ducts, which progressively become larger and less numerous, eventually making their exit from the liver as the right and left **hepatic ducts.** The right and left hepatic ducts join to form the common hepatic duct, which is joined by the cystic duct from the **gall bladder** (vesica fellea). Beyond the junction of the common hepatic duct with the cystic duct, the biliary passageway becomes known as the **common bile duct** (ductus choledochus). The common bile duct travels straight to the posterior surface of the duodenum about three inches beyond the pylorus of the stomach, a small nipple-like projection or technically papilla surrounding the entrance point into the duodenum. The main pancreatic duct empties into the dilatation of the common bile duct, technically the ampulla, which is to be found just liverward from

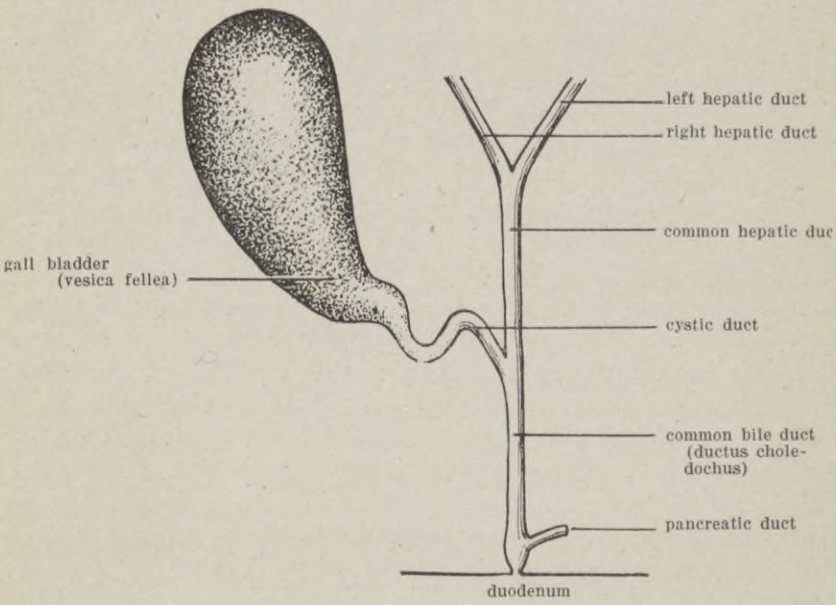


Fig. 55.—Diagram of Bile Ducts.

the papilla. The common bile duct traverses the wall of the duodenum one layer at a time for a distance of over an inch, which arrangement gives a valve action against backflow in case of duodenal overdistention. The walls of the larger ducts and gall bladder are made up of mucosa, submucosa, and muscle layers, the unattached surface of the gall bladder having in addition a peritoneal coating. The mucosa of the smaller ducts is lined by simple columnar cells, whereas the larger ducts are, as usual, of the stratified columnar type.

The old anatomic conception of the gall bladder as a reservoir for bile has required modification, since it has been found out that three or more pints of bile are secreted daily, whereas the gall bladder holds only a few ounces. Bile is secreted actively while food is passing into the duodenum, so the gall bladder may well functionate as a temporary storage reservoir between pumping activities. If the gall bladder is destroyed, other parts of the bile duct may functionally take its place. The gall bladder is attached to the inferior surface of the liver, its free surface approaching the abdominal wall at the right nipple line. The obliterated umbilical vein running about one inch and a half medially to the gall bladder is helpful as a guide to its position.

Practical

Bacterial inflammations of the mucous membrane of the biliary tracts cause a damming up of bile and its absorption into the blood, known clinically as jaundice. Inflammatory disturbances, more especially of the gall bladder, often lead to the formation of gall stones, which themselves tend to keep up a chronic irritation and hence grow by accretion. After these stones have reached a certain size, it becomes a physical impossibility for them to be moved on account of the strict limitations of the normal mucosa as to dilatation. The pain is excruciating if the muscle coats attempt to force the smaller stones through the inflamed ducts. As no medicines as yet discovered will dissolve these foreign bodies, the proper relief is their complete surgical removal. During acute inflammatory stages these foreign bodies may cause complete obstruction of the involved tract, which, however, ordinarily subdivides within a comparatively short time after the beginning of dietary restrictions. As the inflammatory reaction subsides the pressure in back of the obstruction tends to force the bile past the ball-like valve along the passageway. Persistent obstruction usually means that the submucosa has become involved in a stricture process, in practice most commonly due to the inflammatory reaction around common duct stones of long standing or to cancer.

These general principles apply also to urinary and other examples of stone formation.

If the finger be slipped around the right free border of the gastro-duodenal-hepatic omentum, or in other words through the epiploic foramen of Winslow, the hepatic artery, vena porta, and common bile duct may be lifted up en masse. Fortunately for the surgeon, the common bile duct lies superficially and nearest the free border of the omentum, consequently operations can be performed from in front. This surgery calls for a keen appreciation of anatomy, for a moment's reflection must convince any one how serious a calamity it would be to cut the vena porta or hepatic artery or their main subdivisions. An error in the surgery of paired organs may result in the sacrifice of one, whereas a tear in one of the main vessels of the liver must practically always be fatal.

Pancreas

The pancreas is developed as two separate outgrowths from the duodenum, but these parts externally fuse into one. All pancreases have a duct, which empties together with the common bile duct into the duodenum, and in about half of the specimens examined an accessory duct is to be found, which traverses a separate course into the duodenum. The pancreas is a whitish gland stretched transversely across the epigastrium, lying extraperitoneally opposite the first lumbar vertebræ. The celiac axis artery arises above the pancreas, and its branches give the main supply, while the superior mesenteric artery running under the pancreas to the mesentery gives an anastomosing supply. The pancreas is divided for descriptive purposes into a head, a hook process or neck, a body and tail, averaging roughly one-quarter times one times six inches in diameters. The head of the pancreas is encircled by the duodenum, which also remains in close contact with the lower part of the body of the pancreas. Both the pancreas and the duodenum are firmly fixed posteriorly by connective tissue across the vertebral column. The main pancreatic duct receives the minor branches and empties into the common bile duct just before its entrance into the posterior wall of the duodenum. The small pancreatic acini are made up of small groups of cells, which empty into little ducts, and together with other units wrapped up in connective tissue make the visible lobules. In a fresh body the pancreas appears white when in a nonactive state, but pink when engorged with blood.

Practical

Due to their fixed position in front of the vertebral column, the pancreas and duodenum are subject to injuries due to external violence, large pancreatic cysts for example being caused by the reaction of the peritoneal tissues to extravasated pancreatic juice. A gallstone lodged at the duodenal opening of the bile-pancreatic duct may cause bile to enter the pancreas, resulting in the serious catastrophe of acute pancreatitis. The pancreatic secretion in this condition escapes from the ducts and in its spread laterally digests

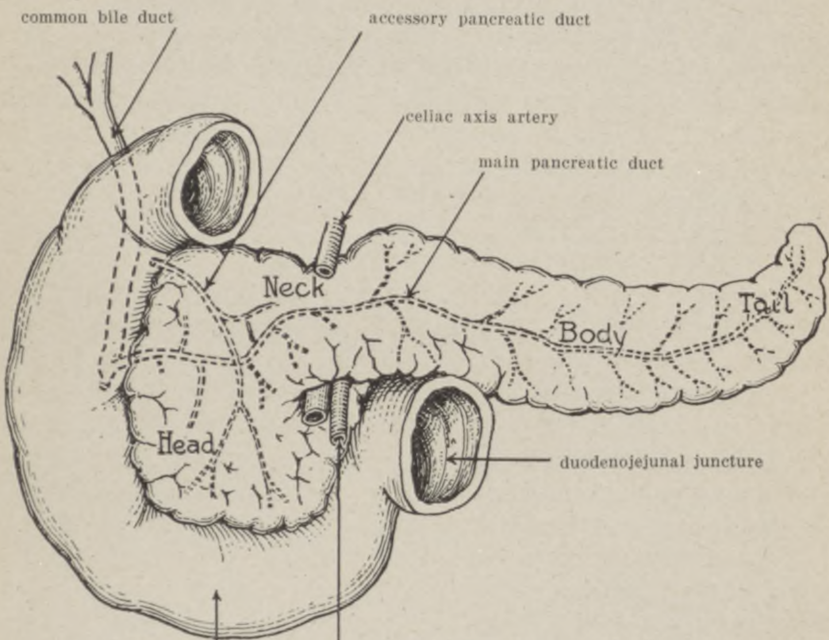


Fig. 56.—Pancreas and Duodenum.

the tissues. The bile physiologically makes the contents of the small intestine alkaline, while the pancreas furnishes the digestive ferments.

Dissection.—The liver, pancreas and duodenum should now be removed from the abdominal cavity en masse for detailed study. The ligaments holding the liver to the diaphragm should be cut, and then the segment of the vena cava inferior running through the posterior surface of the liver cut just above and below this organ. The pancreas and duodenum should then be mobilized from the anterior surface of the vertebral column, and the vessels, nerves and connective tissues holding them to the posterior wall should be cut across. These three organs may then be lifted out.

The anterior surface of the duodenum should be split open in order to examine the entrance of the liver-pancreatic duct at the papilla. By pressing on the gall bladder fluid, if present, can commonly be forced through this duct entrance. The smaller liver and pancreatic ducts should be noted after free sectioning of these organs, and the other points described noted. The preservation of the liver is commonly so poor and the discoloration of the tissues so great that the lobules can not be made out. These lobules are readily to be made out by the unaided eye, however, in a fresh normal specimen.

OTHER ABDOMINAL ORGANS

Spleen (Lien)

The spleen is one of the group of glands which do not possess ducts, and belongs essentially to the blood system. It is the most variable organ of the body in size, varying greatly even during apparent absolute health. It increases greatly and characteristically in size during infections of the body, following interference with its venous outflow and in special blood diseases. The spleen is ordinarily smaller than the clenched fist and has a rounded superior surface in contact with the left diaphragm vault. The **hilus,** situated about the middle of its inferior surface, serves as the passageway for the vessels, nerves, and connective tissues. Except for the region about the hilus, the fibroelastic coat is covered by peritoneum. When the spleen increases greatly in size, it eventually appears below the rib margin at the left nipple line, and then is obviously more exposed to external violence. Its long axis is held diagonally in the body by its ligaments and its edges are notched.

The fibroelastic coat, technically the tunica albuginea, sends in large partitions, which spaces are further subdivided by numerous smaller fibrous partitions. These subdivisions contain numerous **lymph nodules,** about equidistantly spaced, while the larger intervening areas are known as the **pulp.** The pulp, so called on account of its relatively soft consistency, makes up the great bulk of the spleen, and is essentially dilated vessel spaces through which the blood circulates very slowly. The lymphatic nodules and many pulp cells are like the white of an egg in color, but due to the enormous quantity of blood in thin-walled vessels, the organ appears a reddish blue. The cherry red colors normally mean an extra admixture of arterial blood, while the purplish colors are due to an excess of venous blood.

Many cases of surgical removal have proved that the spleen is an organ not essential to life, or, so far as has been noted, to the preservation of health. On the other hand, all anatomic evidence, both developmental and comparative, points to it as an actively functionating gland. The increase in size during acute and chronic infections of the body is strong presumptive evidence that in some way it actively opposes these attacks. The lymphatic nodules develop the lymphatic type of white blood cells throughout life (lymphocytes), while the pulp areas produce red blood cells before birth, but normally cease this activity shortly thereafter. The spleen differs from lymphatic glands anatomically in the intimate contact of its essential cells with large quantities of blood traveling at slow speed, and possibly functionally in that it reacts to bacterial poisons in the blood stream instead of to poisons in the lymph. With the qualification that only part of the blood at any time runs through the spleen, it has much the same relationship to the blood that lymph glands have to the lymph.

The spleen should be examined in position and then be removed from the body for more detailed examination.

Blood Supply of Abdomen

After the removal of the gastrointestinal tract and the various glands just considered, the vessels are well exposed and may then be studied with advantage. Running slightly to the left of the median line and in front of the vertebral column is found the main artery, the **abdominal aorta.** This aorta divides at the junction of the fourth and fifth lumbar vertebræ into the **right** and **left common iliacs.** The common iliacs divide near the sacroiliac joint into a **hypogastric,** which enters the lesser pelvis, and a larger **external iliac,** which continues under the inguinal ligament into the **thigh** and then becomes known as the femoral. The hypogastric artery of the lesser pelvis was formerly known as the internal iliac. Medially directed branches of this hypogastric artery supply the bladder in front and the rectum in back, while between them in the female lies the uterine artery. The laterally directed branches of

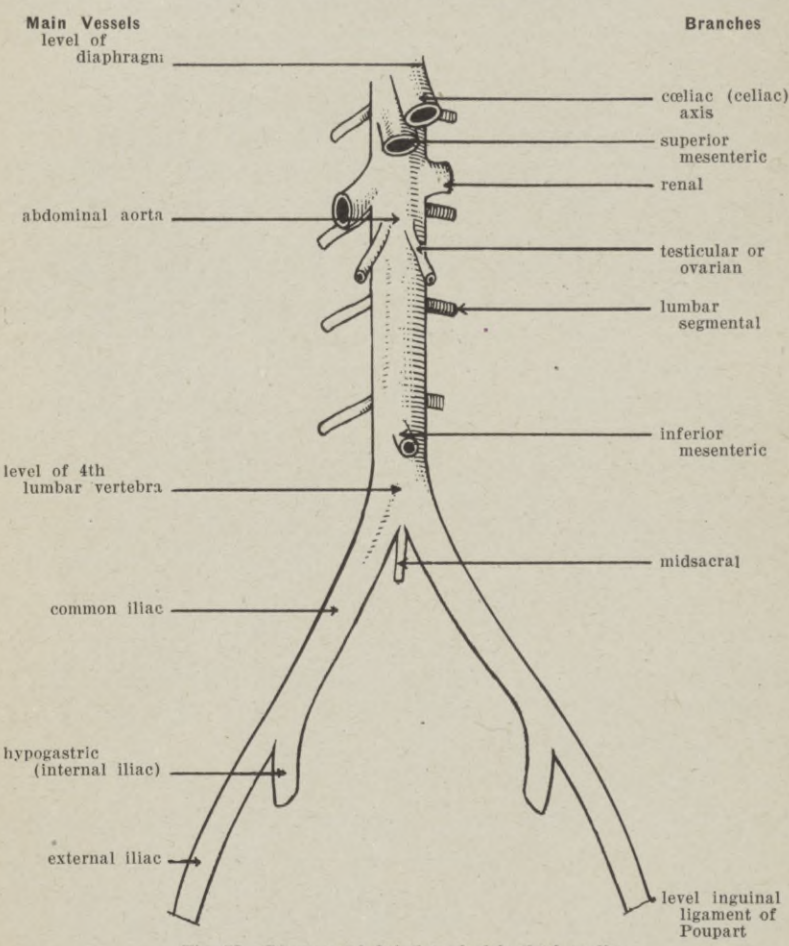


Fig. 57.—Diagram of **Arteries of abdominal cavity.**

this hypogastric artery, the gluteal, the sciatic and the internal pudendal have been considered in connection with their distribution in the gluteal and perineal regions. Inasmuch as these branches originate inside the musculofascial layers of the abdominal wall and pass through the wall to the outside, it is possible for a hernia to work its way out along any of these vessels.

The vein which accompanies the abdominal aorta and lies to its right side, instead of the expected designation of abdominal aortic

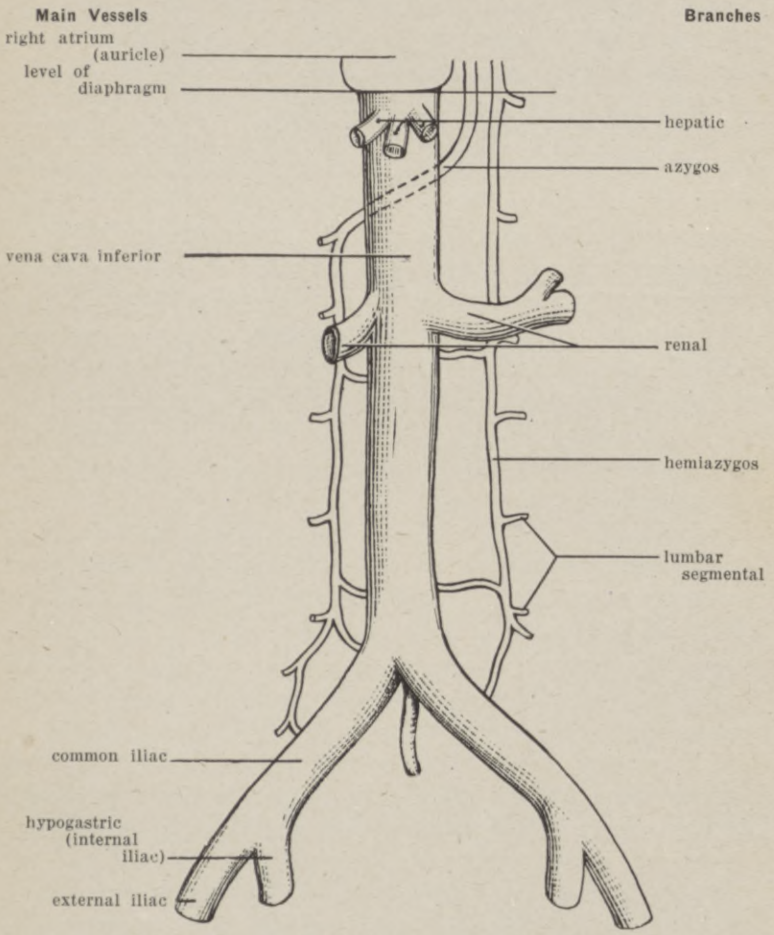


Fig. 58.—Diagram of **Veins** of abdominal cavity.

vein, is known as the **vena cava inferior.** The veins accompanying the common, the hypogastric and the external iliac arteries receive the same names and correspond accurately. The general anatomic rule that a vein does not lie directly between an artery and a bone is broken in the case of the left common iliac vein. This vein passes under the right common iliac artery and directly against the vertebral column in its course to the inferior vena cava.

The most plausible theory for this exceptional occurrence is that the artery tends to support the column of blood and to minimize back pressure. Whatever the true explanation, as a practical result, clotting of blood in the left common iliac vein is very much more frequent than in the right common iliac, no matter from which side of the body the infection starts. The increase of pressure in the capillaries due to venous obstruction causes an excessive secretion of lymph, which collects in the tissues as it can not escape as rapidly as it is secreted. The excessive amount of lymph in the lower extremity stretches the dermis layer to the point at which pressures and counterpressures are equal, when no more lymph will be produced than can be carried off by the lymphatic vessels. Improvement from this condition may take place by reabsorption of the clot, or by the development of an efficient collateral anastomosing circulation. So called "milk leg," following childbirth, is due to an obstruction in the common iliac vein, or its component subdivisions, commonly of the left side.

The large single branches of the abdominal aorta are the celiac axis, and the superior and inferior mesenterics. These vessels have been previously described in connection with the blood supply of the gastrointestinal tract and may now be traced to their origins. The corresponding veins make up the vena porta, its blood traversing a second set of capillaries of the liver before entering into the vena cava inferior.

The most important and largest paired branches are the **renal** or kidney **arteries.** These branches normally follow the routine anatomic rule, that is, the left renal vein crosses anteriorly to the aorta, whereas the right renal artery passes posteriorly to the vena cava, that is, the veins do not lie between the arteries and the bone. Just below this pair from the aorta arise the paired **testicular** or **ovarian** arteries, which maintain the blood supply of these organs throughout life, the left testicular or ovarian vein generally entering the left renal vein instead of the vena cava. A pair of diaphragmatic branches, arising up near the first lumbar vertebra, supply the half of the diaphragm nearest the aorta, while coming off just below these a pair of suprarenal vessels supply the gland of the same name.

Besides these vessels, four pairs of segmental lumbar arteries are to be noted, and also a midsacral branch continuing the aortic course down to the coccyx.

The aorta comes through a fixed opening in the diaphragm opposite the twelfth thoracic vertebra, while the vena cava goes through somewhat higher up the dome opposite the tenth thoracic vertebra. On each side of the vertebral column lies an anastomosing column of large veins, known as the **azygos**, or single veins. These azygos veins connect the inferior vena cava through the diaphragm with the superior vena cava. These veins receive as tributaries the lumbar segmental veins and make several connections with the inferior vena cava.

The arteries and veins should be dissected.

Development of Kidneys

The kidneys are paired organs, which specialize in the excretion of certain waste products from the body. The kidney in the invertebrate animals is essentially segmental in character, each segment having its own excretory gland and duct. This primitive segmental type of kidney, technically the pronephros, is developed very early in the life of the human embryo. It, however, does not functionate in the mammalia group, its function being taken over by the placenta, and therefore soon retrogresses and disappears entirely.

The second type of kidney of embryonic life, technically the mesonephros, consists of tubules, which empty into a common duct running to the cloaca. This kidney type persists throughout life in many of the lower vertebrates, but is never really called into action in the human embryo, its function being taken over by the placenta. The main excretory tube of this kidney is known as the **Wolffian duct**, while a tube formed secondarily alongside is known as the **Muellerian duct**. These ducts persist in the human and functionate, not as parts of the urinary apparatus, but as parts of the genital structures. The association of genital and urinary structures in development is very complex, tubes often subserving combined functions, as is even true in the fully developed male. The Wolffian duct persists as the spermatic duct and utriculus of the male, while the Muellerian duct persists as the ovarian duct and uterus of the female. Small vestigial remnants of the Muellerian tube are to be found near the testicle of the adult male, while remains of the Wolffian tube are located near the ovary.

The third kidney type, technically the metanephros, is a tube-stalk extending up from the bladder portion of the cloaca, at the far end of which the permanent kidney develops.

Kidney (Ren)

The kidneys have the characteristic popularly known shape and are very roughly one times two times four inches in size. The kidneys are enclosed in a firm fibrous and fatty outer capsule, which is freely connected with the posterior part of the abdominal wall, and holds the kidneys in position with their long axes parallel to the vertebral column. The anterior surface of the kidneys is partly covered by peritoneum, whereas the aperitoneal posterior surface is held firmly against the musculature of the posterior abdominal wall. Both kidneys come in contact with the twelfth rib posteriorly, but the right kidney is shoved lower down by the mass of the liver so that only its upper extremity is protected by the twelfth rib. The hilus of the kidney is turned towards the middle line and receives the renal vessels and nerves, while posteriorly the kidney duct or **ureter** leaves the hilus and immediately turns straight downward towards the pelvis. The widened out upper part of the ureter, which attaches to the kidney, is known as the pelvis of the ureter. The ureter travels extraperitoneally across the common iliac vessels, then along the side walls and eventually across the floor of the pelvis to the fundus or base of the bladder.

Microscopic Structure

By painstaking studies of serial microscopic sections it was determined that each kidney is made up of hundreds of thousands of small tubules. Each tubule is a miniature kidney with the following microscopic structure: A **glomerulus,** composed of tufts of capillary vessels, which secrete the watery constituents of the urine, emptying them into the beginning of the tubule. The portion of the tubule leading off from the glomerulus takes a curving course, and is therefore known as the **first convoluted tubule.** The succeeding long thin parts of the tubule make up the ascending and descending

loops of Henle. Then follows a **second convoluted** part of the **tubule,** similar to the first in structure, which empties into a **collecting tubule.** The larger collecting ducts open onto the papillæ which project into the pelvis of the ureter.

Diseases of the glomeruli interfere with the water and salt secretion of the kidney, while disturbances of the convoluted cell areas interfere with the urea type of excretions. The color of the normal kidney cells is translucent, like the white of a fresh egg, but the great quantity of blood present gives the organ its varying reddish-blue color.

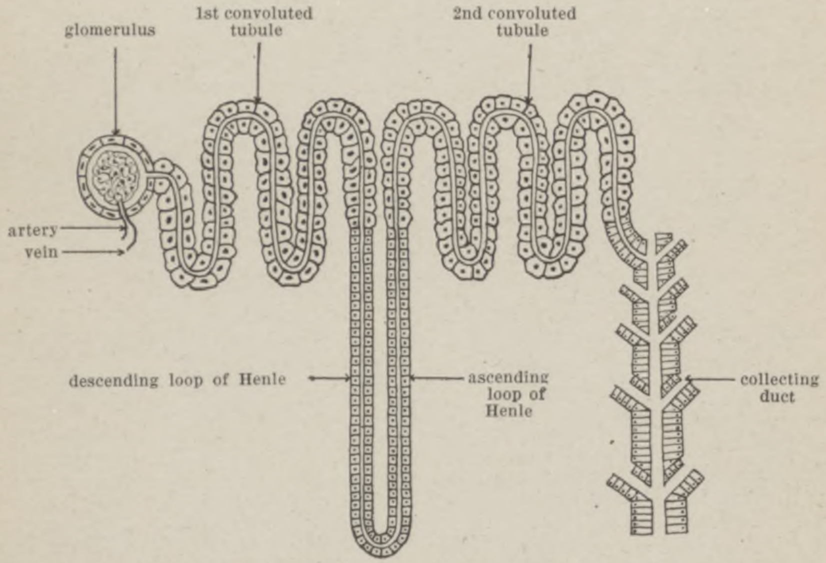


Fig. 59.—Kidney Tubule, diagrammatic (x 100).

Gross Structure

On sectioning a normal kidney an irregular outer zone, known as the **cortex** or shell, is clearly differentiated from an inner zone, known as the **medulla.** The cortex is about one-quarter of an inch average thickness and contains the glomeruli and convoluted tubules, the glomeruli being macroscopically visible as round dots in a fresh kidney. The medulla contains the ascending and descending loops of Henle and the collecting ducts, these structures causing macroscopic radial line markings in a fresh normal kidney.

The whole kidney has a connective tissue framework and is surrounded by a fibrous coat, consequently if the kidney cells are swollen by disease they will bulge on a section of this tunica fibrosa. Chronic low grade inflammations cause an increase of the connective tissue elements of the kidney, with eventually irregular shrinkage in the size of the organ. In chronic degenerations, the fibrous coat

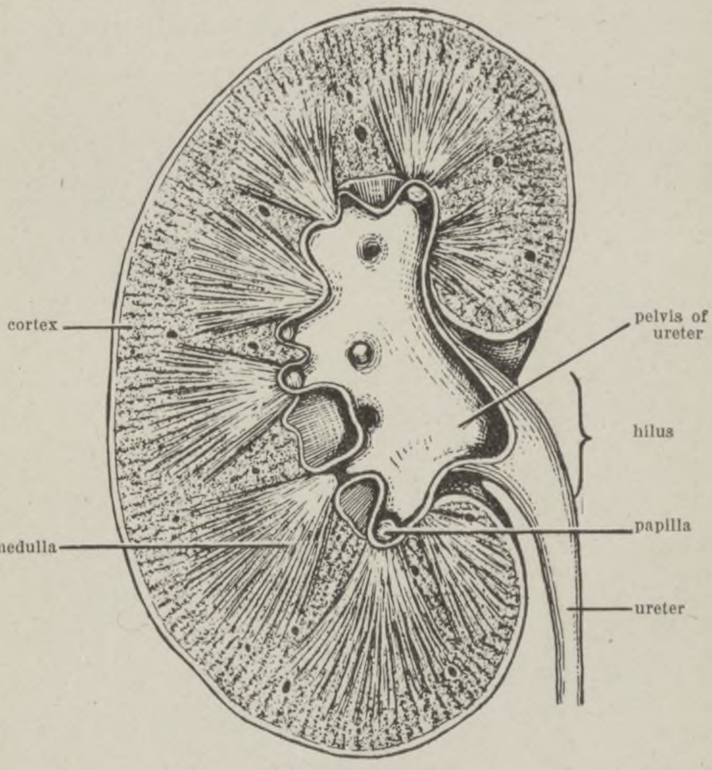


Fig. 60.—Longitudinal section of Kidney.

of the kidney becomes extra firmly attached to the thickened internal fibrous framework. Malformations or destruction of one kidney usually results in an overgrowth or technically hyperplasia of the remaining one.

Dissection.—The relationships of the artery, vein, and ureter should be noted. The kidney should then be lifted out of its bed by cutting the fibrous compartment layer holding it in position against the posterior wall. The ureter should be traced to the bladder and may then be cut at a convenient midpoint. The fibrous coat should be laid open freely along the convex lateral margin of the kidney, and either turned back over the hilus or dissected off. A single long cut, splitting the kidney along its lateral margin and from its upper to its lower extremity, should be carried through into the pelvis of the ureter. If the kidney is normal, the various points noted are readily to be made out.

Suprarenal Gland (Glandula Suprarenalis)

The suprarenal glands are of the ductless type, lying over the upper extremities of the kidneys. These glands fit over the convex surfaces and are very roughly one-quarter times one-half times one inch in diameter. They are composed of a cortex or shell and an inner medullary substance, differing in color and histologic structure. These glands have a liberal blood and especially liberal sympathetic nerve supply. They are essential to health and even to life itself, the secretion being normally absorbed either into the venous capillaries or into the lymphatic vessels.

This secretion has the power of contracting the muscular coats of blood vessels, and consequently this secretion obtained from cattle glands finds a utilization in surgery. If both of these glands are surgically removed or are destroyed by disease, the patient becomes progressively weaker and finally dies as a result of the lack of this secretion.

The suprarenal glands should be removed from the body and cross-sectioned.

Urinary Bladder (Vesica Urinaria)

The part of the urinary bladder from which the urachus arises is known as the vertex, this portion rising or sinking down with the distention or emptying (for urachus see page 179). The fundus, or base, on the other hand, is firmly fixed by fascias in the anterior pelvic portion of the abdominal cavity, which means, of course, above the pelvic diaphragm. The fundus has a continuously stretched triangular area, technically known as the trigonum vesicæ, which has anteriorly the urethral exit and posteriorly the entrance of the two ureters. The ureters come through the different layers of the bladder wall in a valve slant, consequently the greater the bladder distention the tighter are the ureteral openings closed. The bladder is composed of mucosa, submucosa, and muscle layers, and over its superior and posterior surfaces is covered by a reflexion of the peritoneum. The mucosa of the whole urinary tract is lined by a stratified transitional epithelium, differing only from a stratified squamous epithelium in the fact that its upper cells become very large and distended instead of flat and dried out. This change is presumably due to the action of the urine on the superficial cells. The submucosa is the strong layer, which, after distention to about one pint, can stretch no further without great danger of bursting. The muscle layers run in two or, according to some, three directions and planes, the circular fibers reinforced forming the sphincter muscle around the beginning of the urethra. This same description applied to the ureter, with the modification that the distensibility of the ureters is normally less than one-quarter of an inch.

Advantage is taken of distention of the bladder with the raising of its peritoneal reflexion to perform suprapubic, extraperitoneal operations on the bladder, whereas in routine abdominal sections the bladder should be empty. Due to the shortness and distensibility of the female urethra, stones are ordinarily passed from the female bladder before becoming large.

Male Internal Genitalia

The **prostate** gland is a male sexual organ which, as its name implies, lies around the beginning of the urethra beyond the bladder (pro = before; state = stand). This gland lies in the lower pelvic portion of the abdominal cavity—that is, above the pelvic diaphragm—and its capsule is firmly anchored by fascias to the bony walls. The structure of the prostate is glandular, and it empties its secretion by numerous small ducts into the prostatic portion of the urethra. The function of this gland is to pour out a male sexual secretion to prepare the route for and be mixed with the testicular secretions. The prostate surrounds the urethra posteriorly and laterally, and is very roughly one times one times one and one-half inches in diameter, the side-to-side measurement being the greater.

The prostate gland may be readily palpated through the intact anterior wall of the rectum. Gonorrheal infections attack this gland

and in the chronic stages may lurk in the stagnating fluids more or less indefinitely unless cleared out by massage. Firm tumors are formed in this gland, more commonly between the ages of fifty to seventy, which is just before the physiologic decline of the prostate. These tumors, on account of the firm capsule, tend to shut off the urethra, consequently surgical removal of the tumor from inside the capsule is ordinarily required in order to give lasting relief.

Testicle (Testis)

The testicle is made up of hundreds of fine coiled tubules, held together in a very firm fibroelastic coat (tunica albuginea). These tubules are microscopic in cross-section, but when uncoiled are about six feet in length. Their essential function is the development of spermatozoa, which are forced out into a larger coiled duct lying over the testicle, known as the **epididymis** (didymis = testicle).

The epididymis continues as the **ductus deferens** of the spermatic cord, this duct being distinguishable from the other constituents of the cord by the thickness of its walls and its firm consistency. This testicular duct, or ductus deferens, traverses the anterior abdominal wall, as noted in connection with inguinal hernia, and then runs extraperitoneally straight to the prostatic urethra. It traverses the prostate between the lateral and, if present, the median lobe, and empties on each side of a small pocket in the posterior surface of the urethra, known as the utriculus. Just as the ovarian ducts in the female empty into the uterus, so the testicular ducts of the male empty into the outlet of this corresponding utriculus. The testicular secretion travels down towards the urethra, but, controlled by a sphincter muscle, is stored temporarily in a convoluted sac, known as the **seminal vesicle** (semen = seed). These seminal vesicles have the routine mucosa, submucosa, and muscle layers, and their upper posterior surfaces are covered by peritoneum. They are coiled ducts about one-quarter times two inches in size when distended, which lie laterally to the testicular ducts. The lower part of the ductus deferens of the testicle is known technically as the ductus ejaculatorius.

On account of the great strength of the fibroelastic coat, acute inflammations do not cause the testicle proper to swell, but may cause tremendous enlargement of the epididymis. Tumors and the destructive chronic inflammatory infections, on the other hand, may break down the testicular tunica albuginea. The testicular duct has a very strong fibrous coat, which distinguishes it from the other elements of the spermatic cord. Gonorrheal infections, having invaded the urethral end of the deferent duct of the testicle, tend to work back into the seminal vesicles and into the epididymis.

Dissection.—The urinary bladder and the prostate gland should

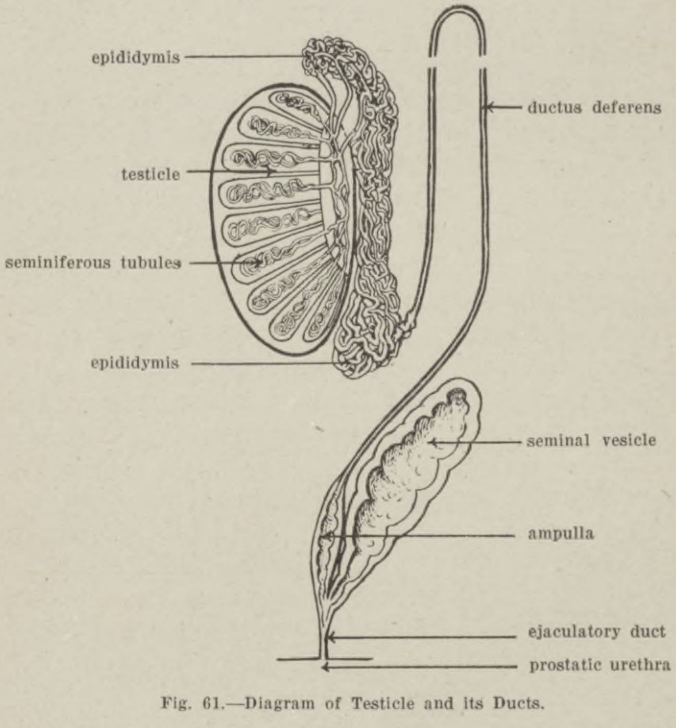


Fig. 61.—Diagram of Testicle and its Ducts.

be studied in position. Then the ureter should be traced to the bladder and a sound passed into the bladder via the urethra. The ductus deferens of the testicle should be traced down to the prostate gland and the seminal vesicles cleared. Then the bladder should be bluntly dissected loose and the urethra cut across just above the pelvic diaphragm, removing the urinary bladder, prostate gland, and the various ducts en masse. The student should now review the attachments of the pelvic diaphragm, which forms the boundary between the pelvic portion of the abdominal cavity and the perineum. The bladder should be opened in its anterior portion and the triangle at its base noted, the urethra in front and the two ureters posteriorly on each side. The prostatic urethra should now be split open anteriorly and the entrance points of the ejaculatory portion of the testicular ducts and the utriculus noted. The opening of the utriculus and the ejaculatory ducts into the prostatic urethra are surrounded by a cratered projection, known as the colliculus seminalis. The median bar and the lateral lobes of the prostate gland may now be sectioned freely. Serial cross-section through the testicle will reveal its gross structure and its firm fibroelastic coat.

Female Internal Genitalia

The **uterus** or, popularly, the womb lies in the pelvic portion of the abdominal cavity—that is, above the pelvic diaphragm. It is a pear-shaped muscular organ, its upper rounded portion being known as the **fundus,** while its lower end, which projects into the fornix, or vault of the vagina, is known as the **cervix.** The normal infantile and senile uteri are distinctly smaller than during the childbearing period, when it is approximately one times one and a half times two and a half inches in diameter. The walls are made up of mucosa, submucosa, very heavy muscle, and, over its upper three-fourths, peritoneum. The mucosa is lined by simple columnar epithelium with crypts, and is partially cast off at each monthly or technically menstrual period. The tremendous increase in the musculature during pregnancy is brought about by a great increase in the size of the individual fibers.

The uterus has a **broad ligament** running to it from each side of the pelvis, which contains between its two layers of peritoneum the vessels, nerves, lymphatics, and connective tissues of the organ. The vessels from the aorta running in the upper free margin of the ligaments are the **ovarian,** while those from the hypogastric artery in the lower part of the ligament are the **uterine.** The **uterine,** or Fallopian, **tubes** lie in the upper part of this broad ligament and functionate by carrying the ova into the uterus. This movement of the ovum is brought about by wave-like motions of the fine cilia on the surface of the uterine tube epithelium. The ends of the uterine tubes are fringed and curled about the neighborhood of the

ovaries, which are situated on the upper posterior surfaces of the broad ligaments just below the tubes. The ovaries, roughly one-quarter times one-half times one inch in size, mature the ova, which are cast off and normally are carried via the uterine tubes into the uterus. The uterus in its normal position lies anteriorly flexed, and this position is aided by the musculofibrous **round ligaments,** which act as guy-ropes. These round ligaments arise outside of the belly wall and, passing through the inguinal canal, insert in the front upper part of the fundus of the uterus. Relaxation of the perineal

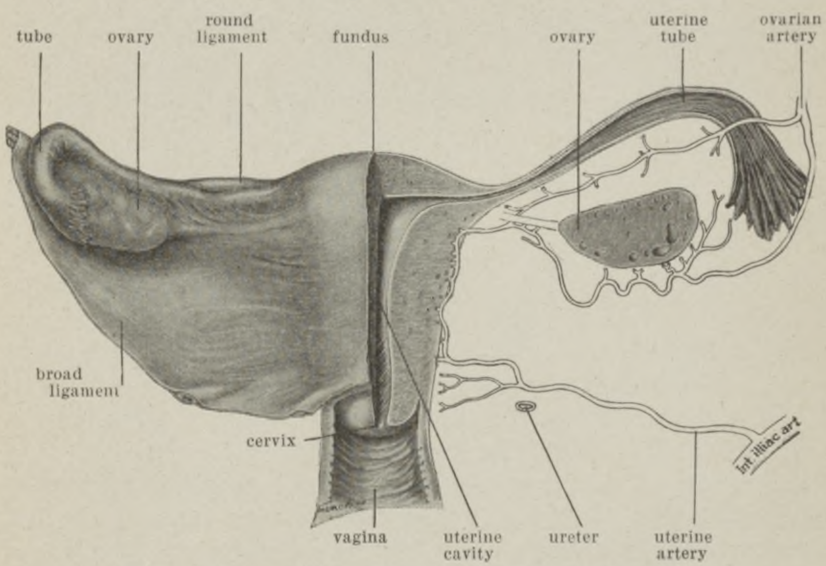


Fig. 62.—**Uterus** and **Associated Organs**, posterior view, right side sectioned.

wall from any cause often causes retroflexion and eventually descent of the uterus.

The mucosa of the vagina is lined by a stratified squamous epithelium and has the usual and also some special extra large compound mucous glands.

Dissection.—The uterus, with its round and broad ligaments, its tubes and the ovaries, should be examined in position. The peritoneum should receive attention, noting its reflexions and the vessels, nerves, and connective tissues in the broad ligaments. The uterus should then be removed, cutting across the round and broad ligaments and the upper part of the vagina. The uterus should then be split open in the median line and its walls, its cavity, and the opening of the tubes into the cavity examined. A probe should be passed through the uterine tubes and these laid open by a free dissection. The ovaries should be incised freely in order to see their interior structure, with the developing ova. The ovaries have a delicate connective tissue framework, a fairly firm fibrous coat, and, except for the hilus, are covered by peritoneum.

Origin of Iliopsoas Muscle

The origin of the psoas muscle from the sides of the bodies of the lumbar vertebræ and the origin of the iliac division from the ilium can now be made out. The course of the combined iliopsoas tendon under the inguinal ligament to its insertion into the lesser trochanter of the femur has been previously noted. The psoas origin explains the occurrence of apparent hip symptoms in diseases of the lumbar vertebræ.

The iliopsoas muscle should be cleared in order that the nerve plexus may be followed out.

Nerves

The five lumbar, five sacral, and the coccygeal segmental nerves supply the lower part of the abdominal cavity and the lower extremity. The nerve supply of the abdominal wall coming from the lower six thoracic and first lumbar nerves can not be traced to the vertebral column until the chest cavity has been dissected. The origin of the lower extremity plexus from the third, fourth, and fifth lumbar, and the first, second, and third sacral nerves should be made out. Inasmuch as the nerves lie extraperitoneal and extrafascial throughout, hernias never follow along the nerve exits. The detailed consideration of the involuntary sympathetic nervous trunks will be postponed until the thorax has been opened. But it is worthy of emphasis again that the nerve supply is segmental—that is, that the same segment of the spinal cord that supplies the skin also supplies the underlying muscles and organs and the sympathetic nerves.

The nerves should be traced out.

Practical

Acute painful infections of the abdominal organs, unless the nerves are out of commission, cause a reflex spasm of the overlying muscalature. While this localizing symptom has great value, it is not, as unfortunately widely considered, a panacea for abdominal differential diagnosis. Painful affections of the serous coverings of the heart or lungs, for example, cause epigastric muscular rigidity, as the nerve supply would lead one to anticipate. The abdominal muscle spasm often fails to differentiate between bile duct, appendix, and right uteral attacks, and in women between appendix and uterine tube infections. All other individualizing symptoms and objective findings must be considered in order to arrive at a proper diagnosis. The muscles of a highly nervous individual react sharply to a minor pain, while people of a stable nervous system may be able to relax their muscular rigidity even though suffering severely.

Chronic inflammatory masses and various tumors, including cancers, are commonly palpable through the abdominal walls. Acute inflammatory exudates are soft in consistency and, lying under a rigid muscle, are not palpable. Marked tenderness on pressure with fever is characteristic for the chronic inflammatory masses, in contradistinction to the lesser tenderness and afebrile course of the tumor-cancer group. The anatomy of the abdominal cavity must be kept clearly in mind in order to be able to interpret properly the palpatory findings. It is, of course, always necessary to compare the anatomic findings with the clinical symptomology, utilizing them as mutual checks.

CHAPTER XI

THE THORAX

The thorax or chest is the rib-supported cavity containing as its most important structures the pair of lungs and the heart. Inferiorly the twelfth thoracic vertebra, the lower border of the ribs, and the xiphoid process form the bony landmarks separating the chest from the abdominal cavity. It is to be especially noted that this is only a superficial boundary, as due to the dome-shaped roof of the diaphragm the abdominal cavity extends well up under the ribs. Superiorly the first thoracic vertebra and the first pair of ribs with their junction to the sternum form the true boundary separating the chest from the neck region, but this is also only a surface demarcation, as the lung cavity domes up an inch or more into the base of the neck. The clavicle lies over the medial part of the first rib and, being superficial, is often arbitrarily selected as a bony landmark between the neck and chest regions.

Bony Framework

The bony framework of the thoracic cavity has been considered in connection with the upper extremity, consequently instead of a repetition here the reader is referred to pages 74 and 75.

Muscles

Muscles belonging to the neck, to the upper extremity, and to the abdominal wall arise by digitations from the outer surfaces of the ribs. The muscles belonging to the upper extremity which overlay the chest are: The pectoralis, major and minor; the trapezius and latissimus dorsi; and the rhomboids, levator scapular, and serratus anterior. Those belonging to the abdominal wall are: The rectus abdominis, the external and internal oblique, and, over the posterior wall, the continuation of the extensor vertebræ group. As none of these muscles, except the serratus anterior, cover the midaxillary space, the ribs are more readily seen and palpated over this area.

When the remains of these muscles just considered have been dissected off, two thin muscle sheets may be found running between the adjacent ribs. The **external intercostal** muscle runs downward and medially, just as the external oblique of the abdominal wall, whereas the **internal intercostal** runs downwards and laterally—that is, at right angles to the external. Layers of deep fascia lie on the outer surface, between, and on the inner surface of these muscles, as would

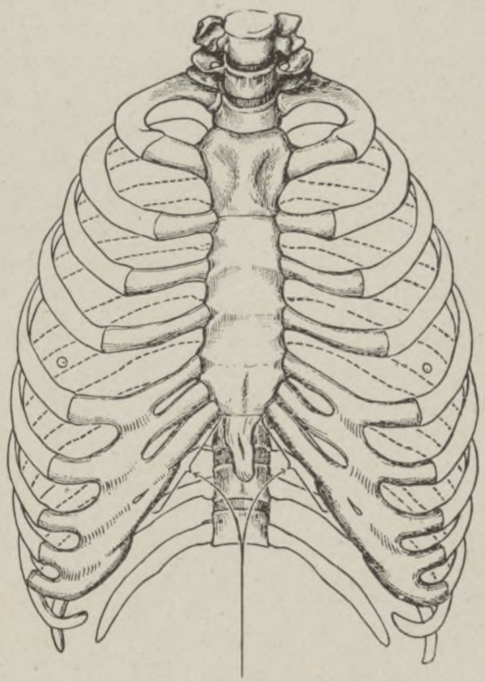


Fig. 63.—Bony-cartilaginous Thorax.

be anticipated. The inner side of this inner fascia is lined by a serous membrane, known as the **pleura.**

The external and internal intercostal muscles correspond to the external and internal muscles of the abdominal wall, both groups at a certain stage of fetal development being distinctly segmental in arrangement. The segmental arrangement of the intercostal persists through life, while in the case of the abdominal muscles this original segmentation is obscured by the fact that the neighboring muscles are not separated by ribs, but grow together into one solid sheet. The fact that the original segmental nerve supply to these abdominal muscles and to the rectus abdominis persists throughout life gives the clue to the early developmental status. The nerves have no method by which they can change from their original position, whereas the vessels supply changes so commonly via the extra development of anastomoses that it is practically valueless as an aid to the understanding of development. The muscles of the extremities are also originally segmentally arranged, but on account of the complicated character of the changes and migrations of muscles this discussion was, generally speaking, omitted.

Vessels and Nerves

The segmental intercostal vessels and nerves run deep and well protected under the lower border of the rib above, forming a depression on the inner surface of the ribs, which is known as the subcostal groove. The vessels do not maintain their original condition, but the anastomosis along the lateral margins of the sternum become the internal mammary vessels. This internal mammary artery lies deep to the costal cartilages and divides at the lower border of the ribs into a diaphragmatic branch and an epigastric branch, the epigastric artery having been previously traced in the rectus sheath towards the umbilicus. The fact should be recalled to mind that the lower six thoracic and the first lumbar segmental nerves, after supplying the chest wall, continue into the abdominal wall.

The remains of the abdominal and upper extremity muscles should be dissected off, and then the muscles, nerves, and vessels in several intercostal spaces should be dissected out.

Respiration

The first and second ribs are held by muscles extending from the cervical vertebræ, and during inspiration are raised up. If these muscles and all the intercostal muscles contract simultaneously, each rib will be drawn up towards its neighbor and the whole thoracic wall raised up, resulting in an increased inside area. The partial vacuum suction causes air to rush into the lungs and is known as the **costal type of respiration**. The contraction of the muscles of the diaphragm pulls this structure down and increases the vertical diameter of the interior of the thoracic cavity, which is the **diaphragmatic type of respiration.** Normally both types of breathing go on simultaneously, but in women, in so far as the corset interferes with movement of the diaphragm, the costal respiration must take up extra work.

While the muscles between the ribs and of the diaphragm are of the voluntary type and can be controlled by will, both these types of breathing are usually performed automatically. This is the classical exception to the general rule in regard to striated muscle fibers.

Types of Chest

Since the beginning of observation of the human body two extremes of types of the healthy chest have been noted. Physically strong people have a well-rounded, relatively deep chest anteroposteriorly, whereas weak people have a flat chest. The strong type is known as the **sthenic**, the weak as the **asthenic** (sthenic = strong). Historically the sthenic chest development was noted to be more common clinically in the apoplectic type of diseases, whereas the asthenic type was more frequently represented in the consumptive type of diseases. The anatomic background for these facts has received much study during late years and is becoming well established. The sthenic type is due to a strong general musculature, which holds the bony framework of the thorax well up, even in full expiration, whereas the asthenic type is due to a weak musculature allowing the thoracic wall to sag down. As anatomic proof of this theory, the relatively short neck of vigorous people is advanced. The cervical vertebræ are of normal size, so the shortness must be due to a high position of the chest wall, whereas in the case of a relatively long neck, conditions are reversed. A further anatomic proof is the wide inferior costal angle in vigorous people, demonstrating that the chest is well raised up in expiration, whereas the narrow costal angle is characteristic for the asthenic type of chest. The inferior costal angle (angulus infrasternalis) is formed by the costal cartilages of the sixth to the tenth ribs on each side as they progress towards the sternum. This angle may be noted to widen out during the raising up of the anterior thoracic wall, as, for example, physiologically during inspiration. The relative depth anteroposteriorly in the sthenic type of people, as contrasted with the relative shallowness in the asthenic type, is further anatomic proof of the high standing position of the thoracic wall.

It is to be borne in mind that any condition which keeps the chest chronically overdistended from the inside, as, for example, asthma, may cause simulation of a sthenic type of chest, even in a weakling. The so-called chicken-breast type of deformity is produced during childhood by some semipermanent obstruction to the flow of air into the lungs. The sternum remains out at its normal position, while the ribs and cartilage tend to be more or less drawn in by a partial vacuum suction.

Relation to General Physique

The sthenic versus the asthenic type of chest is of fundamental importance in any physical examination as a clue to the general physical vigor of the individual. The sthenic type of chest is an anatomic index of physical vigor of stock, while the asthenic type means lack of physical vigor as a heritage. The difference in type can be noted early in childhood, checking up anatomically the ordinary observation that it is to a great extent a hereditary element. Illness and lack of physical activity may at times produce the asthenic type of chest in individuals of physically vigorous stock, while the reverse is equally true.

The common association of the so-called round shoulder with an asthenic type of chest is explained by the fact that both are due to the same factor—that is, weak musculature—which in both cases allows a sagging of the part.

Relation to Abdomen

It is proper to consider in this connection the relation of the type of thorax to conditions in the abdominal cavity. The bust of the "Venus de Milo" has been universally accepted by art critics as the standard model of perfection of figure. This torso has a sthenic type of chest, a full upper abdominal cavity, a narrower waist line, with a proper widening again over the hips. Any anatomist could add to the art critics' statement a guarantee that the abdominal organs are all in proper condition. On the other hand, a narrower upper abdominal cavity and a protruding lower pot-belly are universally associated with an asthenic chest. The narrowed upper abdominal cavity does not allow room for the organs normally belonging in this area, consequently they tend to sag down, the technical word to describe sagging being ptosis. In a markedly asthenic individual, more especially if the general physical strength is for any reason below par, all the abdominal organs pull on and stretch their ligaments until an advanced degree of ptosis is produced. All the intraabdominal organs sag in general asthenia and develop abnormally long and lax mesenteries, omenta, or ligaments, as the case may be. Clinically most stress has been laid on the sagging of the stomach, kidneys, and large intestine, perhaps more in reality than the anatomic changes justified. As the fundamental asthenia must be reckoned with, surgery in this field of endeavor has been able to accomplish comparatively little.

Corsets are worn as a social custom and often to make a woman appear to have what heritage or lack of exercise have denied her—a good figure. The extremely narrow-waisted corset was an artistic and anatomic monstrosity, but the modern corset tends more to follow the natural figure and consequently is not nearly so objectionable. Once women become used to corsets they are uncomfortable without the artificial support; but there is in the normal person no real reason, save vanity or, perhaps, prudery, for their existence. Corsets have earned a place in the treatment of ptoses. The effects of corsets on the limitation of diaphragmatic breathing has previously been commented upon.

Contents of Mediastinum (Cavum Mediastinale)

The mediastinum is the midarea between the two pleural sacs extending from the back of the sternum to the front of the vertebral column, and from the lower part of the neck to the diaphragm. It contains the heart, the largest blood vessels of the body, lymphatic vessels and glands, nerves, connective tissues, the **trachea,** or windpipe, the **esophagus,** or gullet, and a special ductless gland, the **thymus.** The mediastinum is very thin just back of the sternum, the two pleural sacs almost coming into contact.

Dissection.—To open up the chest for an anatomic or postmortem examination the costal cartilages should be cut with an ordinary knife near the end of the bony portion of the rib. Then the diaphragm muscle should be freed from its attachment to the inferior deep surface of the sternocartilaginous section. By lifting up the sternocartilaginous section the attachment of the pleural sacs to its deep surface may be demonstrated. After the pleura is cut from the back of the sternum and the sternum cut across below the sterno-clavicular joint, this section should be removed. The position and size of the internal mammary artery should be noted on the deep surface of the costal cartilages.

Pleural Cavities (Cavum Pleuræ)

The two lungs are developed from the mediastinal end of the tracheal tube, being developmentally extrapleural and, in the strict

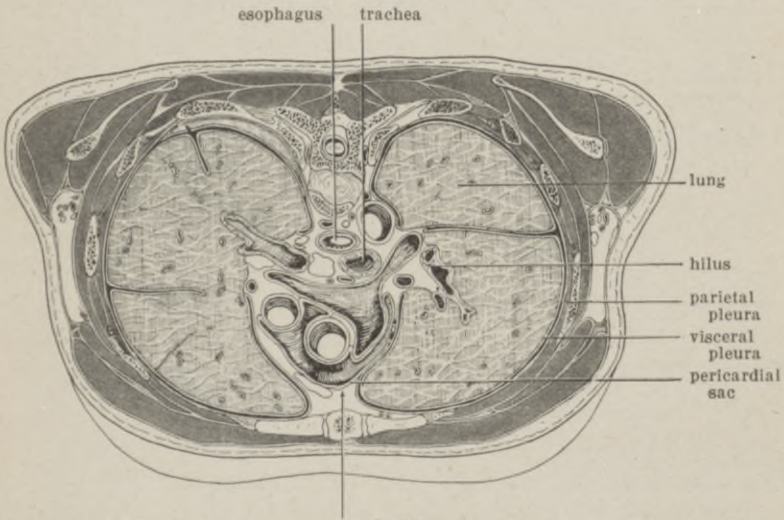


Fig. 64.—Transverse section of **Thorax**, level of fifth thoracic vertebra.

sense of the words, remaining extrapleural. But as the lung develops, it bulges in a layer of pleura in front of it and becomes entirely surrounded by pleura except at the hilus, the lungs being therefore, practically speaking, intrapleural organs. The layer of pleura covering the wall is the parietal layer, whereas that covering the lung is the visceral layer, these two pleural layers being normally held in contact by vacuum suction. The strength of the parietal pleural layer is due to extrapleural fascia layer of the wall. The pleural sac is reflected back at about one and one-half inches from the lower margins of the ribs all the way around, whereas superiorly the domed roof of the pleural sac rises about an inch above the first rib into the base of the neck.

Pleuritis, or pleurisy, is an inflammation of the pleura, characterized anatomically by thickening and adhesion of the surfaces, clinically by pain more marked on deep breathing or coughing. This condition is ordinarily secondary to disease conditions in the lungs. Pleuritis may, in addition, be characterized by a collection of air, lymph, blood, or pus in the pleural sacs.

Lungs versus Abdomen

The surface line between the resonance on striking over the lung and the dullness on striking over the liver on the right side is taken roughly as the sixth rib in the nipple line, the eighth rib in the mid-axillary line and the tenth rib in the scapular line, marking off a horizontal plane. It is obvious that this line would vary with inspiration and expiration, and also that the narrow edge of the lung really extends further down, but this rule is sufficient for practical purposes. Due to the presence of the heart above the diaphragm on the left side, this line is about one-half inch lower on the left side. The absence of great contrast in the normal percussion note on the left side has an influence on the difficulty of diagnosing lung and pleural diseases in this area.

Diaphragm (Diaphragma)

This muscle partition is made of voluntary striated muscle fibers, which are under the control of the will, but ordinarily work automatically—that is, sympathetically. On both surfaces the diaphragm is covered by a serous membrane, which is known as the pleura above and the peritoneum below. These muscle fibers have at least an inch wide origin from the inner surface of the lower margins of the ribs and costal cartilages, and also from the sides of the bodies of the lumbar vertebræ. From all directions these fibers run to a central aponeurosis.

But while these general rules of the diaphragm attachments and relationship are reasonably accurate, they are most apt to fail just when most required—that is, in pus infections of the pleural cavities. These collections of pus in the pleural cavity must be opened at the lowest gravity point in order to obtain complete continuous drainage, otherwise there will be retention with overflow and the poisoning will persist. Therefore the surgical rule of taking out a section of a higher rib and then, with interior guidance, the section from the lower rib, is to be most highly recommended.

The diaphragmatic, or **phrenic nerve** arises from the fourth cervical segment and can be readily traced along the anterior part of the side wall of the mediastinum on its course to the diaphragm. It has an accompanying artery and vein, which anastomose with the aortic diaphragmatic and the internal mammary diaphragmatic branches. The nerve supply is a clue to the development of the diaphragm, which is primarily opposite the fourth cervical segment and progressively sinks during fetal life to its final position. The diaphragm on expiration normally rises to the fourth interspace mammary line on the right side and about one space lower on the left. The abdominal aortic opening in the diaphragm lies opposite the first lumbar vertebra, to the right and about two inches higher lies the inferior vena caval opening, and to the left, still further up, nearer the top of the dome lies the esophageal opening. Nerves, lymphatic ducts, and the azygos veins also take advantage of these passageways.

The attachments of the diaphragm should be noted in the dissected body.

Lung (Pulmo)

The **trachea** divides into two primary **bronchial tubes,** these primary into a number of secondary, the smaller secondary into a number of tertiary tubes, which finally lead down to the smallest bronchial tube, or **bronchiole.** The bronchial tubes are made up of mucosa, submucosa, and cartilaginous rings instead of the usual muscle layers. The object of the cartilage is to keep the passageways permanently open, while the connective tissue inserts between the rings serve to increase the mobility of the tubes. The bronchioles have no cartilage, but in its place a circular muscle layer, which has the power to contract and shut off the air supply. The bronchial mucous membrane is covered by a simple columnar epithelium, while the larger tubes have, as would be expected, the stratified columnar type. Each bronchiole leads into an air sac known as the lobule, the smaller subdivisions of which are known under the term alveoli, on account of their saccular form. These lobules, when distended, are visible to the unaided eye. The air sac is lined by epithelial cells, which are flat when distended by air, while outside of this air sac lies a network of capillaries, connective tissues, and lymphatic vessels.

Oxygen passes through the essential lung cell and the capillary wall into the blood, while carbon dioxide is cast out of the blood into the air space. While this is the main function of the lung, it is known as a matter of common experience that water and volatile substances, such as alcohol, oil of onions, and creosote, for example, are also thrown off. During normal resting condition of the body less than one-quarter of the air in the lungs is changed with each respiration. The lungs are collapsed and functionless at birth, but

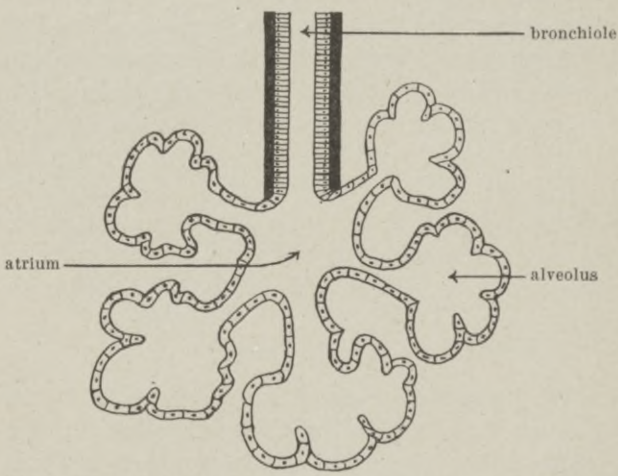


Fig. 65.—Diagram of Pulmonary Lobule (x 100).

after the connection with the placenta is broken the child normally makes its first inspiratory effort. Spasmodic closure of the bronchiole musculature, more common in individuals of a nervous temperament or with certain physical ailments, is known as asthma.

Vessels and Nerves

The **pulmonary arteries** travel along the bronchial tubes and divide into corresponding branches. This artery carries venous blood, which returns as arterial blood via the corresponding pulmonary veins to the heart, this being the classical reversal of the usual conditions. As this venous blood would obviously be unable to care for the lung cells themselves, a very much smaller system, known as the **bronchial arteries** and veins, supply the lung cells. The lymphatic vessels drain into a series of glands in the mediastinum, which, in the case of the city dweller, at least, are commonly full of coal-dust residue. In the lymph or tissue spaces of the lung itself black coal-dust splotches are practically normal for a city dweller. Numerous processes of the sympathetic nerves form a plexus at the hilus of each lung, controlling the arteriole and bronchiole musculature, and for other less obvious functions. At the hilus of the lung the trachea lies posteriorly, but inside the lung all regularity of the hilus structure grouping is soon lost.

Lobes

The right lung is larger than the left in the proportion that ten is to nine, this difference being due to the greater bulk of the heart on the left side. The lungs are divided into lobes by deep fissures, which are so slanted that the upper lobe is continuous with the anterior portion, the lower lobe with the posterior portion. The blunted point of the upper lobe, which extends into the base of the neck, is known as the **apex,** the concaved diaphragmatic portion of the lower lobe as the **base.** The right lung has a small extra lobe between its upper and lower lobes.

Tuberculosis typically attacks the apices of the lungs, while lobar pneumonia typically attacks the bases, very possibly due to gravity differences in the blood supply. Calcareous nodules in the apex, demonstrable during life by the x-ray, are generally to be attributed to a healed tuberculosis. In weak individuals, more especially among the very young or the very old, a small tube bronchitis may eventuate in attacking scattered lobules, called lobular pneumonia. The typical pneumonia of vigorous adult life involves all the neighboring lobules in its spread, and hence is called lobar pneumonia.

Practical

If a water barrel is half full and is struck by a stick, the upper half will yield a long resonant note, while the lower half will yield a short, dull note. This principle is made use of in the percussion of the chest wall for diagnostic purposes. But the amount of fat and thickness of the chest wall will change the resulting note materially, consequently it is customary to compare the notes of the two sides. Percussion must remain always simply an approximation, but is perfectly satisfactory in the localization of complete dullness—that is, solidified lung or large amounts of fluid in the pleural sac. But when both lungs are slightly involved percussion fails, as there is no guide of the normal for this particular individual. The main reliance must then be placed in auscultation—that is, listening over the lung area. If the lung is partially solidified, the rough tracheal sounds are transmitted to the ear instead of the rustling-like sound of normal respiration. Further, the secretions can be heard to rattle back and forth in the various bronchial tubes, these sounds being technically known as râles. If the lungs are seriously diseased, the characteristic symptom is a general blueness of the body. The results of physical examination must always be checked up against the clinical course.

Dissection.—The lungs should be examined in position, and then one hilus should be dissected, demonstrating the vessels and bronchial tubes. By pulling the lungs out of their respective cavities and cutting across at the hilus, the lungs may be removed from the body for detailed examination. If the lung has been attacked by acute or chronic diseases, adhesions will have to be separated between the parietal and visceral layers of the pleura.

Heart (Cor or Cardia)

The heart is the muscular pump, which functionates by starting and maintaining the circulation of the blood. Inasmuch as the lymph—for practical purposes a diluted blood without the red blood corpuscles—is being constantly secreted by the capillaries, the circulation of the lymph is indirectly dependent upon the heart action (for a discussion of lymph see p. 59). These fluids are the medium of exchange, allow for specialization of labor in the body, and, of course, are essential to life. The circulation in plants depends upon other factors, but all animals, except the lowest orders, have some type of muscular pump.

Simplest Type

A very simple type of heart may be noted among the invertebrate animals, which is practically a single vessel with an enlarged extra heavily muscled section. This primitive heart contracts rhythmically in a wave-like motion from its entrance, the vena cava, to its exit, the aorta. The blood is thus forced onward through the capillaries of a series of gill or lung arches and then passes into a dorsal aorta. This dorsal aorta gives a segmentally arranged supply to the body, the blood eventually returning via veins to the heart. The early heart of the human embryo is of this type.

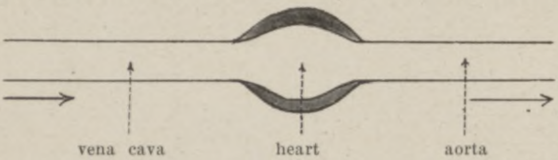


Fig. 66.—Heart, single chamber type, no valves.

Valves

When in the more complicated hearts high pressure must be developed to force the viscous blood through the system, dependence is no longer placed upon the direction of the contracting wave to maintain the direction of flow, but valves are introduced. The mechanism of the valve does not interfere with the flow of blood in the proper direction, but when pressure is lower in the preceding chamber the valve shuts and prevents backflow, technically regurgitation.

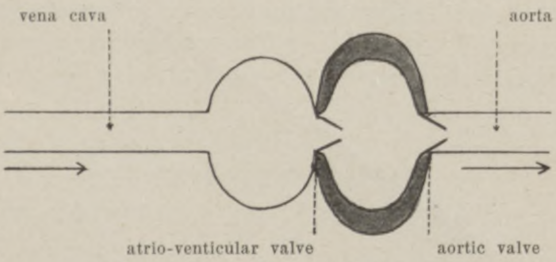


Fig. 67.—Heart, double chamber type, with valves.

Chambers

The more complicated hearts have at least two chambers, the first of which acts as a receiving station and the second as a pumping station. The receiving subdivisions are known as the **atria**, this word meaning hallway, while the more muscular pumping subdivisions are known as the **ventricles**, on account of their stomach-like shape. The atria were formerly known as the auricles, on account of their alleged resemblance in shape to the external ear, this term being still retained, but now being limited to the curled-up tips of

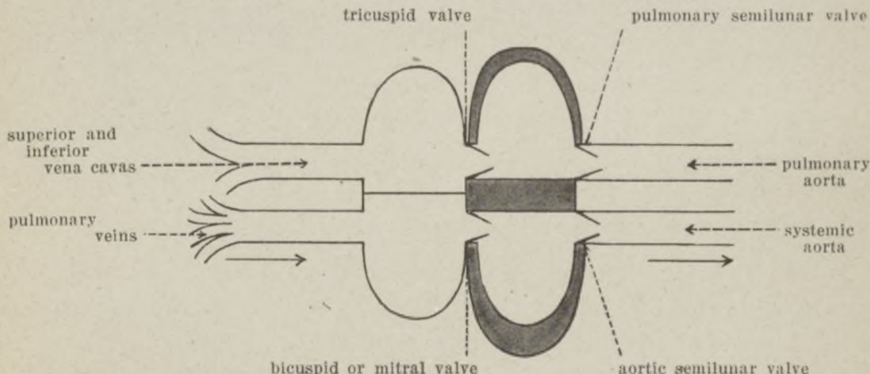


Fig. 68.—Heart, four chamber type, with valves.

the atria. Further, all the birds and mammals have the heart partitioned into halves, one half carrying the venous blood through the lungs and the other half the arterial blood through the general circulation. In the human being after birth the right atrium and ventricle pump the venous blood through the lungs, while the left atrium and ventricle pump the arterial blood through the general circulation.

Flow Through Heart

Venous blood enters the right atrium from the superior and inferior vena cavas. No valves are to be found in the vena cavas or in the main subdivisions which make up these veins, being an exception to the general rule in regard to veins. The venous blood is forced by a contraction wave of the right atrium, which starts at the vena cavas and forces the blood over the **tricuspid valve** into the right ventricle. Contraction of the right ventricle then closes the tricuspid valve and forces the blood over the **pulmonary semilunar valve** into the pulmonary aorta. The arterial blood from the lungs enters the left atrium through the valveless pulmonary veins and then is forced over the **bicuspid,** or mitral, **valve** into the left ventricle. Contraction of the left ventricle closes the bicuspid valve and forces the blood over the **aortic semilunar valve** into the general circulation.

In actual practice the two atria contract simultaneously and then the two ventricles contract.

Fetal Circulation

The circulation during intrauterine life differs from the condition after birth, as logically must follow from a consideration of commonly known facts. The fetus develops but does not use its lungs until after birth, consequently the pulmonary artery would subserve no useful function by pumping a great quantity of blood through the lungs. The bulk of the blood is therefore short-circuited through a vessel, the **ductus arteriosus,** from the pulmonary aorta to the thoracic—that is, the systemic—aorta. This ductus arteriosus ceases to functionate after birth and eventually disappears, practically without leaving a trace. Now, inasmuch as little blood returns via the pulmonary veins from the lungs during fetal life, the left side of the heart would be without a sufficient supply to work with were it not for the **foramen ovale** opening in the atrial partition. This foramen allows the blood from the right atrium to cross over into the left atrium. The mixing of the fetal bloods causes the blood in the arteries to be of a mixed arteriovenous type, distinctly bluish, but still perfectly satisfactory for all requirements of the fetus. The fetal heart develops four chambers, but on account of the ductus arteriosus and open foramen ovale functionates as a two-chambered heart. Part of this mixed blood is being sent out constantly to the placenta, where it is oxygenated and then returns to the right atrium, mingling with the returning venous blood of the general circulation.

Summarizing the course of the blood from the heart to the placenta and return: A mixed arteriovenous blood is pumped from the left ventricle into the aorta, or from the right ventricle via ductus arteriosus to aorta, then through descending thoracic aorta, abdominal aorta, and common iliacs, and then through the umbilical arteries to the placenta; here it becomes oxygenated and returns as

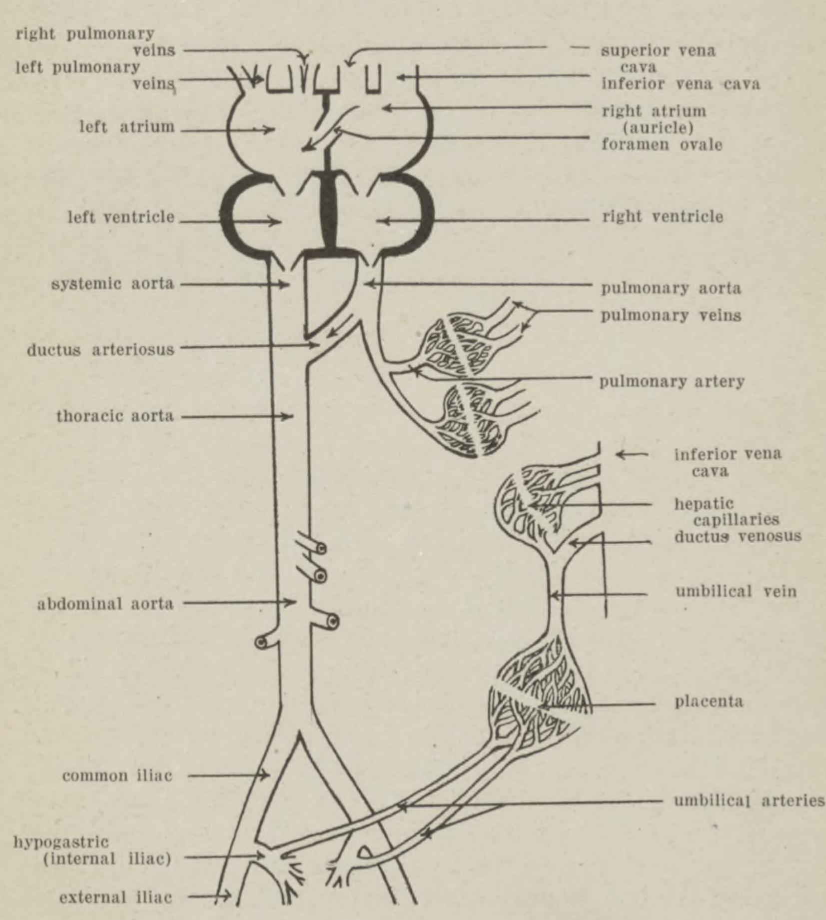


Fig. 69.—Diagram of Fetal Circulation.

pure arterial blood via the umbilical vein, the bulk short-circuits via the ductus into the inferior vena cava, while a smaller portion goes through portal veins of liver into inferior vena cava, and then into right atrium (for umbilical vein see p. 179). The ductus arteriosus, the foramen ovale, the ductus venosus, and the umbilical arteries and veins are fetal structures, which normally cease functionating after birth and disappear or exist only as vestigial remains during later life. The umbilical vein carries the only pure arterial blood of the embryo or fetus; all the ordinary veins carry venous blood, while the arteries carry a mixed arteriovenous blood.

Due to congenital malformation or disease of the systemic aortic orifice, the ductus arteriosus and the foramen ovale may have to remain open and so cause the condition known clinically as "blue baby." This persistence of the fetal condition after birth is incompatible with a normal expectancy of life.

Pericardium

The heart lies in the lower half of the mediastinum, with its lowermost part in contact with the central aponeurosis of the diaphragm. It lies in a pericardial **fibrous sac,** which is attached to the diaphragm and the various connective-tissue layers of the mediastinum. This fibrous sac is lined by an endothelial serous sac, which has parietal and visceral opposing layers.

The pericardial sac should be opened freely.

Gross Anatomy

Approximately two-thirds of the heart lies to the left of the median line. The heart bears a direct ratio to the size and strength of the individual, which is approximately given as equal to the individual's clenched fist. However, this estimate is very relative, as the amount of distention of the cavities obviously would influence materially the apparent size. The left ventricle makes a blunted point known as the **apex,** which is the lowest and farthest to the left part of the heart. During life this apex strikes the chest wall with every muscular contraction of the heart and is found normally in the fifth interspace just medially to the nipple line. As the **base** of the heart and its posterior portion are held fixed by their vessel connections, any increase in the size of the heart, due either to increase in muscle mass or dilatation or both, will result in carrying the apex beat farther down and farther to the left side. The left border of the heart is overlapped by the lung, but over a small triangular area near the sternum the pericardium can be entered without traversing the pleural cavity.

The pulmonary aorta and the thoracic aorta arise from the base of the heart and run upward, the pulmonary arching over the thoracic aorta. A pair of **coronary arteries** arise from the ascending portion of the thoracic aorta as it leaves the heart and make an encircling crown in the atrioventricular groove. These coronary arteries send off branches to supply both atria and ventricles, the corresponding veins emptying, as would logically be expected, into the right atrium. These vessels are obviously important, and modern research has shown, in contradistinction to former beliefs, that their branches anastomose freely. The anterior and posterior **descending branches** of these coronary arteries run down over the partition between the right and left ventricles, and consequently furnish a surface demarcation. The atria lie mainly in back of the heart, but their irregular tips, the auricular portions of the atria, project around the origins of the pulmonary and thoracic aortas.

Dissection.—By lifting the apex of the heart out of the pericardial sac and cutting across an inch distant from the heart the veins, the vena cavas and the pulmonaries, and the arteries, the thoracic and pulmonary aortas, the heart may be removed from the body for detailed examination.

Atria

The atrioventricular groove with the coronary arteries, also the entrance of the superior and inferior vena cavas into the right atrium, and the entrance of the four pulmonary veins into the left atrium, are all readily demonstrable. The inferior and posterior surfaces of the ventricles are molded by the diaphragm, which also, due to its doming shape, approaches the atria posteriorly.

The posterior walls of both atria should be opened freely and, if the circulation has chanced to give out slowly, clots formed just before death will have to be removed. The walls of the atria are thin and internally, are irregular, due to the projection of muscle bundles. The inner surfaces of the atria, however, are smooth, due to the endothelial lining, which is continuous with that of the blood vessels. A valve-like, thin area in the middle of the interatrial partition, the normal adult reminder of the fetal foramen ovale, is ordinarily readily demonstrable.

The atria should now be dissected off.

Valves (Valvulæ)

The removal of the atria makes the interior of the ventricles visible except in so far as the bicuspid and tricuspid valves interfere. The normal bicuspid valve admits two fingers, while the tricuspid is slightly larger. The valves are rather thin sheets of white fibrous tissue, covered on all surfaces by endothelium, and when closed their free margins meet liberally. The bases of the valves are materially thicker and blend with the connective tissue of the muscular ventricular walls (annuli fibrosi). The surfaces of the valves towards the atria are perfectly smooth, while the ventricular surfaces are made irregular by the attachment of muscle tendons, which functionate by preventing the valves from being forced back into the atria.

The aortas should be trimmed off to within a half inch of their exit from the heart. The systemic aorta has materially thicker walls than the pulmonary aorta, in conformity with the relative pressures these vessels respectively are called upon to withstand. The blood clots should be removed from these vessels, and then the three semilunar cusps of each vessel will become visible. The free edges of the cusps overlap, while their bases blend with the connective tissue elements of the arterial walls. These valves differ from the atrioventricular valves in their materially smaller size and in that they do not have musculotendinous support. The two coronary arteries should be noted coming off from the beginning of the thoracic aorta, the origin of these vessels being partly hidden by the cusps, except when the aortic valve is closed.

Various disease processes may attack and partly destroy these valves, almost exclusively in the harder worked left side of the heart. A leaky valve would obviously increase greatly the work of the heart. The extra work of a leaking valve causes a dilitation of the heart, and eventually an increase in the musculature in order to keep up the function. The valves may be stuck together, resulting in too small an opening, technically known as stenosis, or they may be eaten away, resulting in an overlarge opening, causing regurgitation.

Ventricles (Ventriculi)

The muscular wall of the left ventricle is normally over twice as thick as that of the right ventricle, on account of differences in the power required. The thickness of these walls varies materially with the amount of dilatation, consequently relative weights of the ventricles are of more importance than relative measurements. Whereas the right ventricle wall in health averages less than one-eighth of an inch, the left is commonly over one-quarter of an inch in thickness. The muscle bundles extending into the ventricular cavities and attached via tendons to the valves are known as papillary muscles (adjective of papilla or nipple). Microscopically the heart is made up of a special striated type of involuntary muscle cells. The general fact that the muscle fibers interweave and make whorls can be made out, but the details of this arrangement can only be followed in specially prepared specimens. The partition between the two ventricles, marked externally by the anterior and posterior descending branches of the coronary arteries, is so situated that the bulk of the anterior wall is made up by the right ventricle, while the bulk of the posterior wall is made up by the left ventricle.

The condition of the musculature would obviously be a very important element in any heart disturbance. Diseases of the coronary vessels, in so far as they interfere with the nutrition of the heart musculature, may result in heart collapse or even sudden death. Stab wounds of the ventricles do not ordinarily allow blood to escape from the interior of the cavity, because the uncut paralleling fibers draw tight and close the opening. The patient, however, commonly bleeds from cut coronary branches, so as to distend the pericardium. This blood, under pressure in the pericardial sac, tends to check the flow of blood into the atria, which is under low pressure, and causes the heart to become short of blood for pumping. This occurrence calls strenuously for surgical interference, as the opening of the pericardial sac, with release of blood clots, may give instantaneous relief. A collection of air, lymph, or pus in the pericardial sac may produce the same symptoms and great relief may follow its removal. Greatly increased intraabdominal pressure may press the diaphragm against the heart, which diminishes the blood supply of the atria, resulting in serious circulatory disturbances and even, in patients with diseased hearts, in sudden death.

The walls of the ventricles should be opened in order to examine the muscles and the ventricular cavities. The incision through the ventricular wall should parallel the septum, the position of which may be determined externally by the anterior and posterior descending interventricular branches of the coronary arteries.

Vagus Nerves

The pair of vagus or tenth cranial nerves leave the base of the skull, traverse the neck and the mediastinum, and give off important branches to the heart. These nerves regulate the beat of the heart to the requirements of the body, this portion of the vagus belonging to the sympathetic or automatic nervous system. If these nerves are severely injured or destroyed, the heart may continue to beat, but without rhythm or force commensurate with the general needs of the body. The impulses down the vagus nerves determine the rhythm of the atria, which normally fixes the rate of the ventricles. At the end of the atrial beat the message is carried along a muscular **bundle of His** from the atrial septum to the ventricular septum. If this bundle of His is destroyed the vagus message can not pass to the ventricles, which still contract rhythmically, but at about half the normal rate, known clinically as heart block.

The vagus nerves hold a course between the trachea and the esophagus and are therefore not visible in an ordinary exposure. The esophagus holds a course just in front of the vertebral column, while the trachea lies just anterior to the esophagus. The vagus nerves should be located on each side of the mediastinum by removing the parietal pleura just in back of the hilus of the lungs. The left vagus may be readily located, as it crosses the lateral surface of the arch of the aorta, while the right vagus should be sought for just in back of the main right bronchial tube. The vagus nerves should then be traced upwards towards the neck, and downwards along the esophagus to the stomach. The left vagus eventually supplies the anterior surface of the stomach, developmentally the left surface, while the right vagus supplies the posterior surface, developmentally the right surface. The larger branches from the vagus nerves in the upper part of the mediastinum join the cardiac plexus, while smaller branches are given off to the lungs, to the trachea, and to the esophagus. As the left vagus crosses the arch of the aorta, the left inferior laryngeal nerve is given off. This nerve curves around the arch of the aorta from the lateral side medially and then progresses upward to the larynx. The peculiar roundabout course of this nerve is due to the descent of the heart and aorta during embryonic and fetal life. The word vagus means wander, as in vagabond, and in view of the facts noted above is surely justified.

The vagus nerves should be identified and traced out.

Sympathetic Nerves

The sympathetic nerve supply comes from all the cervical and the upper thoracic segmental nerves, the three cords into which these fibers join supplying their respective sides of the heart. The fact that these nerves rise way up in the neck would lead us to surmise that the heart was situated in the neck during the early stage of development. The heart, as a matter of fact, is developed in the neck and only secondarily sinks down in the mediastinum to its protected situation in back of the ribs. These nerves essentially control the blood supply of the coronary arteries, regulating it according to the requirement of the heart.

The common reference of cardiac pain to the side of the neck, more commonly the left, and radiating down the arm is presumably to be explained on this anatomic basis. Pericardial pains are located over the heart and, if referred, belong to the fourth to the eighth thoracic segmental nerves. Other pains are located by the patient in the heart itself, but cardiac pains are not commonly referred along the vagus nerves.

Thoracic Arteries

The thoracic aorta is divided, for descriptive purposes, into an **ascending** portion, an **arch,** and a **descending** portion. The ascending aorta at its commencement sends off the right and left coronary arteries, while the arch on the right side sends off an **innominate** artery, and on the **left** side a **common carotid** and a **subclavian.** The innominate artery (arteria anonyma) will later be demonstrated to divide in back of the clavicle into its component right common carotid and subclavian subdivisions. The descending thoracic aorta sends off the lower nine pair of segmental intercostal branches and the pair of bronchial arteries. The aorta arches to the left side of the mediastinum, while the descending aorta progresses towards the middle line, holding a course just in front of the bodies of the thoracic vertebræ.

Thoracic Veins

The subclavian vein joins the **jugular,** the head and neck vein, on both sides of the body just posterior to the junction of the first rib with the sternum. These two so-formed **innominate** veins (venæ anonymæ) join at the right of the sternum just in back of the second rib to form the **superior vena cava.** The intercostal, bronchial, and smaller mediastinal veins empty into the respective right and left

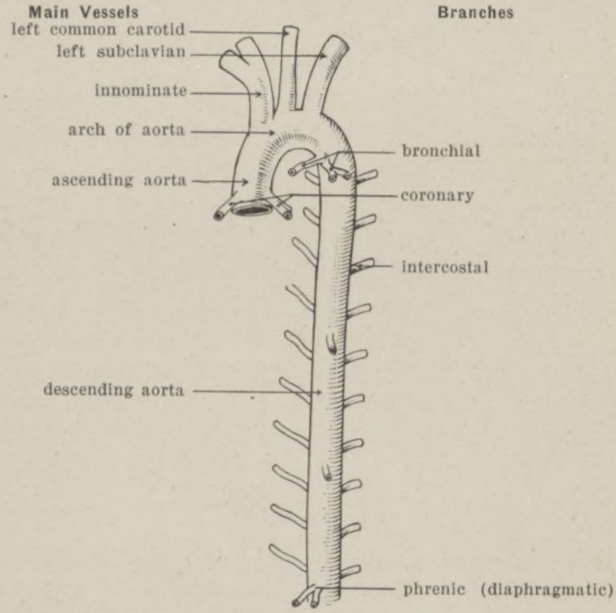


Fig. 70.—Diagram of thoracic Arteries.

azygos venous trunks, which form an anastomosis between the superior and the inferior vena cavas. The left azygos vein (vena hemiazygos) terminates in large cross-branches to the right or major azygos vein (vena azygos), which empties into the superior vena cava.

The arteries and veins should be completely exposed in the lower part of the mediastinum, but the clearing of those in the upper third of the mediastinum should be postponed until the neck dissection has reached the proper point.

Thoracic Lymph Duct (Ductus Thoracicus)

The main lymphatic duct of the body is a continuation of the abdominal lymph duct and is known as the thoracic lymph duct. It holds a course just in front of the vertebral column, runs approximately in the median line and, when distended, is over one-eighth of an inch in diameter. When distended with lymph it appears translucent and consequently is readily distinguishable from a vein; but

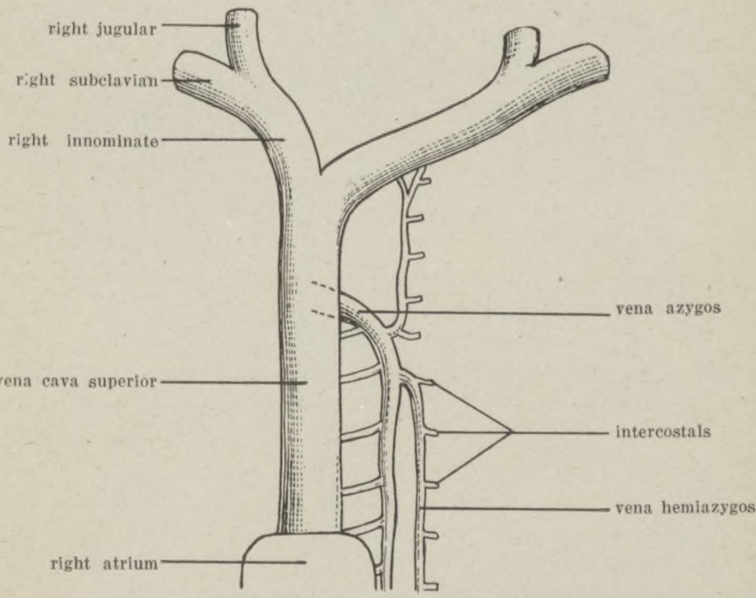


Fig. 71.—Diagram of thoracic Veins.

in a dissecting-room body it may be difficult to identify. The thoracic duct turns to the left in the upper part of the mediastinum and lower part of the neck, and enters the left subclavian vein near its junction with the jugular. Embryologically the thoracic lmyph duct is made up of two parallel ducts, one on each side of the median line, but as development proceeds, the left duct becomes the main one, while the right normally drains only its side of the head, neck, arm, and chest. Variations in the adult thoracic duct and anastomosing connections with other veins are very common findings.

Blockade of the duct may cause lymphatic fluid to collect in the left pleural sac or in the peritoneal cavity. This is the classical example of edema due to obstructed outflow, most edemas being due to an excessive production of lymph. Inasmuch as the digested fat from the intestines is carried through this duct into the circulation, this lymphatic fluid becomes milky-like after fat digestion and is known as chylous fluid. The widened-out abdominal portion of the duct, over the first and second lumbar vertebræ, is known as the cisterna chyli.

The lymph duct should be dissected out.

Esophagus and Trachea

The esophagus holds a course just in front of the vertebral column, deviating at its lower end to the left en route to the stomach. The walls of the esophagus are made up of mucosa, submucosa, and muscle layers, with the usual characteristics. The esophagus passes posterior to the pericardial sac. The trachea maintains a position just in front of the esophagus, and as a result the further down it is traced the deeper it lies from the anterior surface of the thoracic wall.

The lower half of the esophagus should be dissected, but the detail dissection of the upper half of the esophagus and the trachea had better be postponed until the neck region is opened up.

Gangliated Sympathetic Trunks

The sympathetic nerves of the abdominal and thoracic regions now deserve more detailed study, as the next step in dissection will destroy these regions. Although in details the cervical sympathetic differs from the thoracic and abdominal sympathetic systems, the general underlying principles are the same (for general discussion see page 63).

Each segmental nerve of the body just after it emerges from the intervertebral foramen sends a branch to, and receives a branch from a ganglion of the sympathetic system. These ganglia are situated on the sides of the vertebral bodies, in the thoracic region situated well back towards the intervertebral foramina, while in the cervical, lumbar, and sacral regions their position is more anterior. A pair of ganglia exist for each segment of the body, except in the neck region, where the original eight ganglia are fused into three.

The neighboring ganglia are connected by large strands of nerve processes, hence the phrase gangliated sympathetic trunks. At every ganglia there is the possibility of a multiplication of the number of nerves—that is, one axis-cylinder process may run to a dozen or more ganglia cell bodies. As a matter of fact, a great multiplication of sympathetic nerves commonly does take place at the various ganglia.

These ganglia of the sympathetic trunks send branches to each

Fig. 72.—Diagram of Sympathetic Trunks.

segmental nerve en route to the various structures under control of this system. Other branches follow the fibrous compartments of the arteries and, in the case of the chest and abdomen form the three large intermediate **prevertebral plexuses**, the cardiac, the epigastric, and the hypogastric, and other prevertebral plexuses of lesser importance. The branches from the neck and upper thoracic area to the cardiac plexus can only be seen satisfactorily after the neck has been dissected. The branches from the lower six thoracic ganglia should be noted to form into three cords, known as the splanchnic nerves, which join the epigastric plexus. The branches from the lumbar and sacral ganglia should be traced to the hypogastric plexus.

These prevertebral plexuses contain ganglia and connect up with the microscopic **visceral ganglia and plexuses** in the various organs.

The descending thoracic aorta and the abdominal aorta should now be removed by cutting the lower thoracic and the abdominal segmental arteries. The azygos veins and the inferior vena cava should also be removed. Minor clearing will now expose the gangliated cord of the sympathetic trunks from the upper thoracic region down to the coccyx.

Thymus

The thymus is a ductless gland held by connective tissue in the upper half of the mediastinum and extending anteriorly to the posterior surface of the sternum. It varies materially as regards size, being large during childhood, but characteristically after puberty decreases to a small indefinite mass. The thymus is developed from the epithelial lining of the throat and, while the gross and microscopic appearance of the adult degenerated gland is very similar to lymphatic tissue, modern research has shown it to be functionally and anatomically a distinct structure. Its function is unknown, though in the normal adult, judging from its shrunken condition, it has but little to do. In certain lymphatic and other ductless gland diseases the thymus increases greatly in size and, presumably, in function, in such a state being made up of two distinct lobes and filling up all the otherwise unoccupied space of the mediastinum above the pericardium. Some cases of unexpected sudden death during childhood show enlargement of the thymus gland, together with general lymphatic enlargement, as the only unusual postmortem findings. The theory advanced that the enlarged thymus presses on the trachea, mechanically shutting off the air supply, has not received convincing anatomic or clinical proof.

Vertebral Column (Columna Vertebralis)

As a matter of dissection convenience it is preferable to consider this series of bones, which continue throughout the body, at one time instead of in connection with the separate cervical, thoracic, and abdominal subdivisions. Inasmuch as the abdominal and thoracic divisions can be freely dissected and the neck considered sufficiently for our purposes, it is well to consider the whole vertebral column at this stage.

The bony framework consists of seven cervical, twelve thoracic, and five lumbar vertebræ, also the sacrum and coccyx. As each upper vertebra has progressively less superimposed weight to carry, we would expect to find each upper vertebra to be smaller and weaker than the neighboring lower vertebra. This, *a priori* expectation, is in fact, absolutely borne out. It is important to note, however, that the size of the spinal cord and the space allowed for

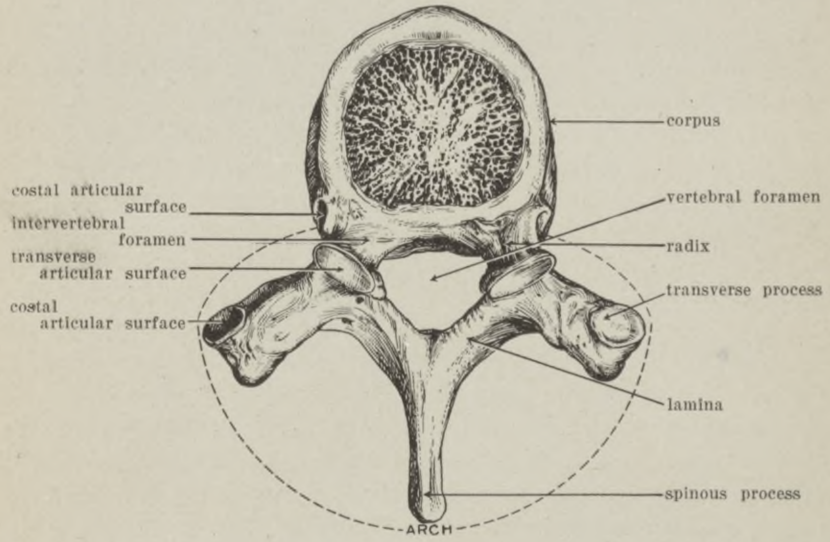


Fig. 73.—Tenth thoracic Vertebra.

it does not vary materially at the different levels. This space for the spinal cord is known technically as the vertebral foramen. The bodies of the twelve thoracic vertebræ are, in addition, characterized by the presence of joint surfaces, where the heads of the ribs attach, the second to the ninth ribs, inclusive, notching two neighboring vertebræ. The vertebræ are typically made up of a **body** (corpus vertebræ) and an **arch** (arcus vertebræ), the bodies of the vertebræ forming the anterior surface of the spinal cord foramen, while the arches surround the spinal cord laterally and posteriorly. The arch of each vertebra is subdivided into a pair of **roots** (radix), a pair of

transverse processes, a pair of **lamina**, and a **spinous** process, as illustrated in diagram (lamina = thin flat plate). The spinous and transverse processes serve as points of origin and insertion for various muscles and tendons, the length of these projections giving excellent leverage power.

The bodies of the vertebræ, considered in downward sequence, are separated by progressively larger fibrocartilaginous discs, which serve as cushions against shocks and allow for segmental flexibility. The bodies are held together by strong **anterior** and **posterior longitudinal ligaments** over the respective surfaces, these ligaments plus the fibrocartilaginous discs making up a series of amphiarthrodial joints without synovial cavities. The transverse processes have opposing articular surfaces with strong capsular ligaments—that is, two joints with separate synovial cavities for each vertebra. The lamina are held together by firm ligaments, which, on account of the admixture of yellow elastic fibers, are known as the **ligamenta flava** (flava = yellow). The **interspinous** and **intertransverse ligaments** are of white fibrous tissue, except for a slight extra admixture of yellow elastic fibers throughout the neck region. The intervertebral foramina lie between the roots of the vertebral arches, these spaces being materially larger than the vessels and nerves making use of them.

With the body extended to its maximum, all these ligaments tend to lock the vertebræ in position, whereas with the body bent forward in flexion the vertebræ have considerable lateral rotary possibilities. As in the other regions of the body, the muscles play a predominating part in maintaining the alignment of the vertebral column, the ligaments feeling the strain only after the muscle power has been overcome. Therefore patients, after the muscle relaxation of an anesthetic, unless the normal curves of the back have been supported by cushions, very commonly complain of pain in the ligaments of the vertebral column. Fact is, pain in the vertebral column is one of the commonest of all symptoms, being found in most acute diseases and whenever weakened muscles are overstrained. Bone diseases, commonly due to tuberculosis, may attack the bodies of the vertebræ, whereas fractures ordinarily involve only the vertebral arches. Dislocations of the vertebræ are extremely uncommon except in the cervical region, where the opposing bony surfaces are materially smaller. The destruction of the bodies of the vertebræ causes the condition known popularly as hunchback, technically as kyphosis.

Extensor Vertebræ Muscle Group

The large, powerful muscle group on each side of the vertebral column is essentially one bundle throughout the lumbar region and is known as the **sacrospinalis** (O. T. erector spinæ). This muscle mass arises from the back of the sacrum, from the posterior portion of the iliac crest and from the spines, lamina, and transverse processes of the lumbar vertebræ. The **quadratus lumborum,** lying deep to the sacrospinalis and running from the crest of the ilium and the transverse processes of the lumbar vertebræ to the twelfth rib, belongs functionally to this muscle group. The term sacrospinalis is restricted to the muscle group in the lumbar region, but this extensor group continues over the thorax and through the back of the neck, terminating eventually at the base of the skull. The lateral border of this extensor muscle group in the thoracic region can be traced on the ribs by the roughening, the ribs at this point changing their direction sharply, which is known as the angle of the ribs. The muscle group makes a heavy, fleshy mass over the loin, but is spread out and thinner across the back of the thorax. The muscle strands tend to terminate at each rib, another musculotendinous strip arising and carrying the bundle upwards. This muscle over the back of the chest is rather artificially considered to be made up of three main bundles, a lateral **costalis** division, an intermediate **longissimus** division, and a median **spinalis** division. An extraordinary number of names are given to the component parts of this extensor group in the thoracic and neck regions, but these names are only of minor practical interest and consequently will be disregarded. The nerve and blood supply of this muscle group is segmental, each level having its separate supply, which means that the muscle group itself was originally segmental in origin.

This dorsal extensor vertebræ muscle group is opposed by the ventral flexor group of the lateral and anterior surfaces of the neck, chest, and abdomen. Due to their intrinsic strength and their mechanical advantages, these extensors are very much more powerful than the opposing flexors, as is well demonstrated whenever any irritant causes both groups to contract to their utmost. Meningitis, lockjaw, or strychnine poisoning, for example, cause the body to bow backwards in extension, so that in extreme conditions only the sacrum and back of the head touch the bed.

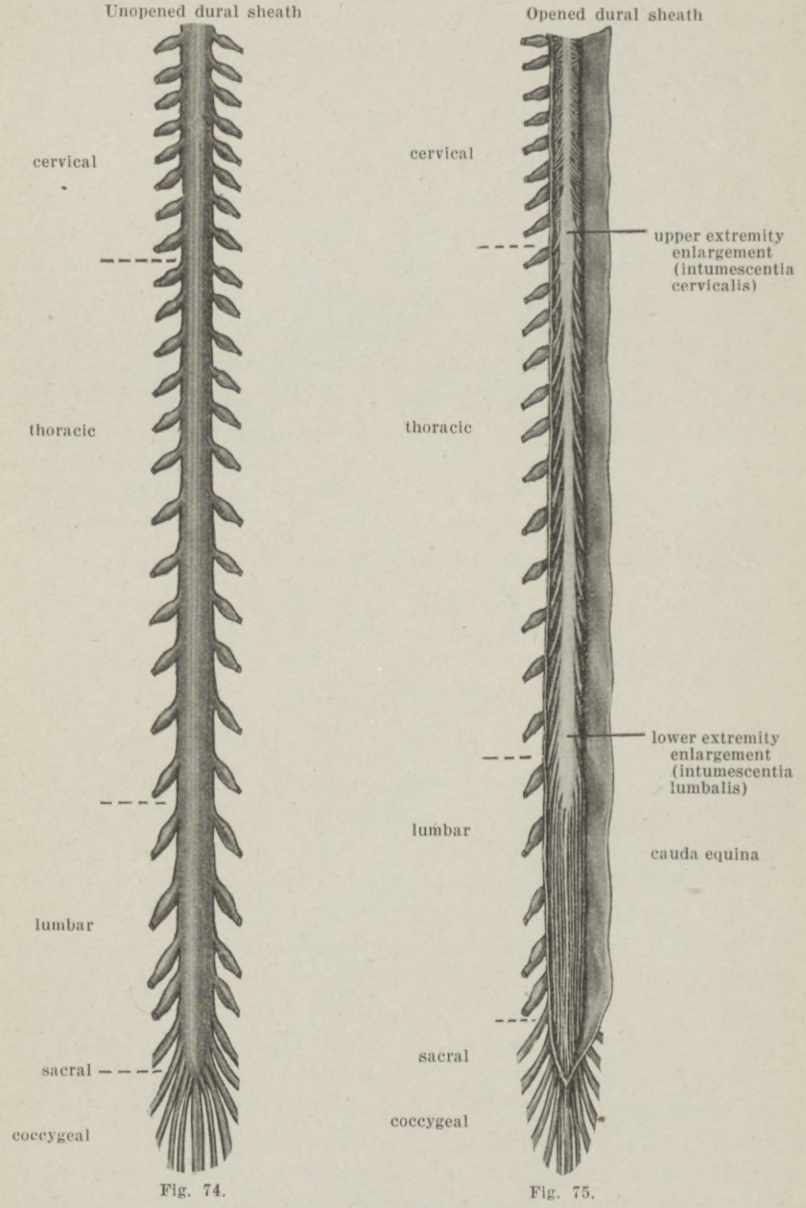
This muscle group should be dissected throughout the abdominal and thoracic regions.

Curves

The normal vertebral column is not a straight line, but has liberal curves anteroposteriorly. The primary lumbar curve anteriorly is compensated for by a thoracic curve posteriorly, which tends to hold the body in balance above the midpelvis. In very stout people with a large protruding abdomen the upper parts of the body must be thrown far back in order to maintain balance, which yields a pompous, strutting appearance, characterized anatomically by exaggerated curves. Thin, weak people, on the other hand, tend to have the backbone approach nearer a straight line, unless the muscle and ligament power gives way. Normally in strong individuals with symmetrical general development, the spines, in a standing position of the body, tend to approach a medial straight line. With weak musculature, however, lateral curvatures primary and compensating may become marked during developmental years and may even become permanently fixed.

Spinal Cord (Medulla Spinalis)

The medulla spinalis, or, popularly, spinal cord, lies in the bony vertebral canal, well protected from ordinary injuries. The intervertebral foramina, which lie between the roots of the vertebral arches, serve as passageways for the vessels and nerves connecting with the spinal cord. The lamina meet with the body in full extension, but with the body bent forward in full flexion a space of a quarter inch or more exists between the lamina in the lumbar and cervical regions. This anatomic fact should be recognized in attempting to obtain the fluid from around the spinal cord, technically known as spinal puncture. With the body fully flexed, a hollow needle with an obturator is run through the skin just on either side of the median line, and directed upwards and medially down to the lamina, and then raised or depressed until it pierces the ligamentum flavum. The removal of the obturator, if the end of the needle is in proper position inside of the dura mater, will allow the escape of cerebrospinal fluid.



Figs. 74 and 75.—Spinal Cord (medulla spinalis).

The spinal cord proper is very much shorter than the canal, terminating opposite the first lumbar vertebra, while only nerve trunks traverse the lumbar and sacral parts of the canal. The upper nerves run straight out to their foramina, while those below the first lumbar progressively run further inside the canal before emerging through their foramina. The size of the nerves varies materially according to the segment of the body, those to the upper and lower extremities being much the largest. The cord varies in size at different levels, but averages approximately one-quarter inch anteroposteriorly by three-eighths of an inch in width. The long paralleling nerve trunks below the first lumbar vertebræ have been named the **cauda equina**, a comparison to a horse's tail.

Dura Mater, Arachnoidea, and Pia Mater.

The spinal cord is encased in a very tough fibrous membrane known as the dura mater (dura = tough; mater = mother). This protecting dura mater is separated by a space from the bony walls of the vertebræ, but, on the other hand, is firmly anchored by connective tissue and that part of the dura mater which blends with the sheath of each segmental nerve as it emerges through the intervertebral foramen. The inner surface of this dura mater is coated by an endothelial serous lining, while the thin connective tissue of the outer surface of the spinal cord receives a similar covering, which is known as the pia mater (pia = soft). Between the dural and pial endothelial layers lies a very delicate membrane, known as the arachnoidea, a comparison to a spider's web. Anatomists are agreed that this arachnoidea is a complete membrane throughout and that there are normally no spaces through which fluid may pass outwards. The pia-arachnoidal endothelial space is filled up during life by a thick layer of fluid under pressure, which is known on account of its continuity with the brain as the cerebrospinal fluid. This fluid tends to evaporate out of dissecting room bodies and consequently is not ordinarily demonstrable. It will be reconsidered later in connection with the detailed study of the brain and spinal cord. The dura-arachnoidal endothelial layers are physiologically in actual contact, the smoothness of these surfaces serving to reduce friction to a minimum. Whenever the dura mater is punctured, the exploring needle practically speaking always goes through the arachnoidea as well and cerebrospinal fluid pours out. The arachnoidea, together with its minor semipartitions through the pia-arachnoid space, presumably serves to limit wave action in the cerebrospinal fluid.

Dissection.—In order to expose the spinal cord, the muscles, the spinous processes, and the lamina must be removed down to their junction with the transverse processes. The surgeon nowadays generally uses some type of bone-biting instrument, but for practical dissecting room purposes a strong, sharp chisel and heavy mallet are satisfactory. After these parts have been removed, the dura should be split open along its posterior medial surface from the upper thoracic region down to the lower part of the sacrum. Due to the evaporation of the cerebrospinal fluid the dura will be found collapsed around the spinal cord, but during life it would appear round and distended. The endothelial lining of the dura and pia maters should be noted. Then the spinal cord should be sectioned in the upper thoracic region and lifted out from inside the dural sheath, cutting the segmental nerves successively near the intervertebral foramina. Variations in size and in intradural lengths should be noted. The spinal cord should then be put aside in a moist place and kept for detailed study in connection with the consideration of the brain.

The articulation of the head of the ribs with the bodies of the vertebræ or neighboring vertebræ should be examined. Then some of the series of costotransverse joints should be opened up. Several of the series of intertransverse articulations should be opened up both in the lumbar and in the thoracic regions. In the lumbar region these joints are in a vertical plane, while in the thoracic region these joints are tilted half-way to the horizontal plane. The anterior and posterior longitudinal ligaments should be noted and several of the intervertebral discs cut across with an ordinary knife in order to note their macroscopic structure.

The slightly movable symphysis pubis joint has flat opposing surfaces held together by powerful interosseous ligaments, but these ligaments may be easily cut by an ordinary knife. By manipulating the hip bones the irregular sacroiliac joint surfaces should be noted and then these surfaces should be dissected and forced apart. The sacrum is suspended by strong interosseous ligaments from the iliac portion of the hip bone, being often justly referred to as the inverted keystone of the pelvic arch. The opposing surfaces of the sacrum and iliac portion of the hip bone show all types of irregularities, but in spite of this careful fitting and the great strength of the interosseous ligaments, major and minor injuries to this joint are now recognized to be far from uncommon. Disturbances in the very numerous joints of the vertebral column and pelvis are now receiving clinical recognition, and a serious attempt is being made to separate true joint cases from under the old-fashioned blanket diagnosis of lumbago or sciatica.

As a matter of dissection convenience the vertebral column should be cut across about the fourth thoracic intervertebral disc, and then the lower part of the body may be discarded.

CHAPTER XII

THE NECK

Bony Framework and Landmarks

The bony skeleton of the neck consists essentially of the seven cervical vertebræ. The first and second vertebræ are very much modified from the type plan as will be detailed towards the end of this chapter, the third, fourth and fifth are the typical cervical vertebræ, while the sixth and seventh are more like the thoracic vertebræ. The spinous processes of the second, sixth, and seventh vertebræ come to the surface, but the short double-pronged spinous processes of the other cervical vertebræ lie deep and are covered by a modified continuation of the interspinous ligaments. In the neck of a fairly strong individual the transverse processes are too well covered by muscles to be palpable from the surface. The anterior surface of the bodies of all the cervical vertebræ, however, are covered only by the esophagus and its prolongation upward, the pharynx, and therefore the upper ones can be readily palpated through the mouth.

Many cervical muscles and ligaments attach to the base of the skull and to the lower jaw, technically the **mandible.** The **ligamentum nuchæ,** the elastic continuation of the interspinous ligaments in the cervical region, raises up a prominence in the midline at the back of the base of the skull. This is known as the **external occipital protuberance,** which terminology means that the occipital bone also has a protuberance internally. Just in back of and below the ear the sternomastoid muscle raises up the **mastoid process** of the temporal bone (mastoid = nipple-like). A curved line running between these two points represents the attachment of other neck muscles to the base of the skull and forms the demarcation of the neck from the scalp, while anteriorly the inferior border of the mandible separates the neck from the face region. Inferiorly the first thoracic vertebra, the first pair of ribs and the upper part of the sternum form the bony separation of the neck from the thorax. There is no sharp line of demarcation between the neck and the upper extremity, various structures from the neck continuing uninterruptedly into the arm area.

Connected by muscles and ligaments to the lower jaw and to the base of the skull is suspended the horseshoe-shaped **hyoid bone.** This bone is palpable from the surface just under the mandible, the open part being faced towards the vertebral column. Swung below the hyoid bone lies the **thyroid cartilage,** which helps to form the larynx or voice-box at the top of the trachea (thyroid = shield-shaped). Below the thyroid cartilage lies the **cricoid,** or signet-ring, **cartilage,** which has its narrow band portion in front and its broad signet portion behind. Below the cricoid cartilage follow the rings of the trachea, which are, however, so thickly covered as not to be readily palpable from the surface. The marked anterior projection of the thyroid cartilage, much more prominent in the male, is known as the laryngeal prominence or popularly as Adam's apple. The hyoid bone and the thyroid and cricoid cartilages, although movable up and down by muscular action, are important localization landmarks of the neck.

Superficial Layers

The skin is as would be anticipated very thick over the exposed posterior portion of the neck and thin over the protectable anterior surface.

Boils and eventually multiple boils or carbuncles are much more common over the thicker posterior skin surface.

The subcutaneous fatty layer contains the routine cutaneous arteries, veins and nerves, and the superficial venous system. The segmental nerves of the upper four cervical foramina emerge from the deep fascia opposite the transverse processes of their respective vertebræ, sending branches forward and backward, and also divisions up over the posterior portion of the scalp and down over the clavicle. The main superficial venous trunk, the **external jugular,** runs straight down from the posterior portion of the jaw to about the middle of the clavicle, where it enters the subclavian vein of the deep venous system. Other veins of the superficial venous system are located over the anterior and posterior portions of the neck, but these are so small and so irregular in their arrangement that they scarcely deserve special names.

The platysma is a special skin muscle, which runs vertically downward from the face over the front half of the neck to terminate over the upper part of the chest (plat = flat). This type of skin muscle is more highly developed in the lower animals, its popularly known function being to shake the skin rapidly in order to scare off flies. This thin muscle sheet has some surgical importance, because if the fibers are cut transversely the pull of the muscle eventually tends to widen out the scar.

The skin and the subcutaneous fatty layer should be dissected.

Deep Fascia

The deep fascia completely encircles the neck and is stronger over the more muscular posterior portion than over the front. It

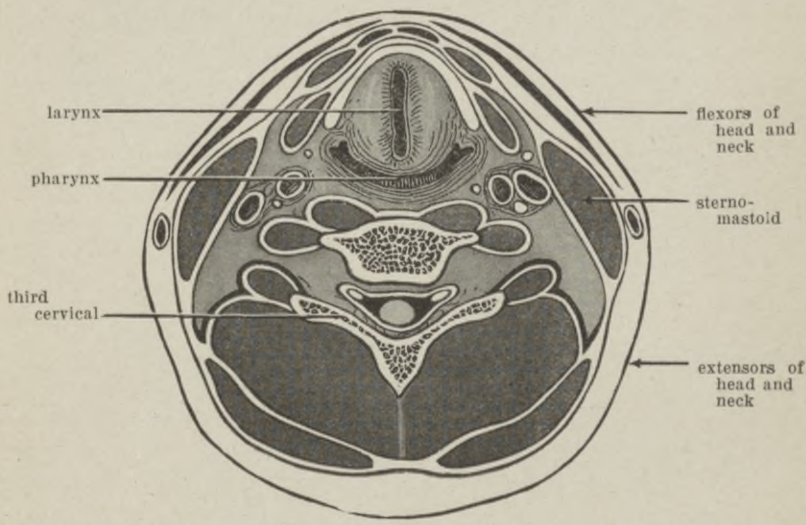


Fig. 76.—Diagrammatic fascial compartments of Neck.

sends in partitions between the muscles and muscle groups, and either stops at the bony limits of the neck, or as in the case of the mediastinum and shoulder girdle continues into these areas. Layers of deep fascia also form compartments for the main vessels and for the special organs.

A few lymphatic glands lie along the superficial jugular veins, but most of them lie along the deep jugular vein. This accounts for the relative frequency of deep abscesses of the neck, and emphasizes the diagnostic and surgical importance of the fascia.

Extensor Vertebræ Muscle Group in Neck Region

The extensor vertebræ group of muscles in the back of the neck is much more powerful than the opposing flexor group, as is demonstrated by the commonly known phenomenon in connection with the muscular spasms of spinal meningitis, lock-jaw or strychnine poisoning. A source of some confusion is the presence of various muscles in this area, which normally have nothing to do with the movements of the head and neck, but belong to the upper extremity or to the thorax. The popularly known columnar elevations of the back of the neck, one on each side of the median line and extending from the thoracic region to the base of the skull, are produced by these extensor vertebræ muscle groups. Some of these muscles insert into the base of the skull, and are therefore, strictly speaking, extensor capitis muscles. This muscle group is covered by the aponeurotic origin of the trapezius muscle, and in the lower half of the neck by the origin of the rhomboids, while the levator scapulæ is intimately embedded in the group. After the remaining parts of the trapezius and rhomboids have been dissected off, the splenius sheet of muscle is exposed to view. The **splenius** muscle arises from the upper thoracic and lower cervical spines, runs upward and laterally and splits into two divisions, the cervical division inserting into the transverse processes of the upper cervical vertebræ, the capitis division into the curved line between the external occipital protuberance and the mastoid process. After examination in position the splenius muscle should be divided at the midpoint and turned back towards its origin and its insertion. This dissection will expose the large **semispinalis** muscle, which arises from the transverse processes of the upper thoracic and lower cervical vertebræ, and divides also into cervical and capitis divisions (O.T. complexus). The capitis division lies superficial to the cervical and inserts into the base of the skull well in back of the head-neck articulation, while the cervical division inserts into the spines of the upper cervical vertebræ. This semispinalis is obviously the continuation of the spinalis division of the thoracic region, and whereas there are also continuations of the longissimus and costalis divisions, these are of distinctly lesser size and importance. The consideration of a deeper group of muscles, which lie just in back of the head-neck articulation will be postponed until the upper vertebræ and their articulations are taken up in detail.

Flexors of Neck and Head

The flexors of the neck and head lie in the lateral and anterior portions of the neck. The scalene muscle group of the lateral part of the neck, however, has as its sole function the elevation of the first two pairs of ribs, while other muscles of these areas have subsidiary functions as will be brought out in the detail considerations.

Sternomastoid (Sternocleidomastoideus)

This important muscle of the neck arises by its main tendon from the upper part of the sternum and by an accessory head from the medial third of the clavicle, coursing diagonally across the neck backwards and upwards to its insertion into the mastoid process of the temporal bone. This muscle is sometimes injured during the birth process, resulting in the so-called congenital wry neck, the head in this condition being turned to one side and flexed on the chest. If both sternomastoids act at the same time flexion of the head and neck is produced. The most important vessels and nerves of the neck, specifically the internal jugular vein, the carotid arteries and the vagus nerve lie under this muscle, as much protected as is possible in so exposed an area. The sternomastoid is also important as a landmark, as it is used to divide the neck into an anterior and a posterior triangle, so named on account of their relation to this muscle. The anterior triangle is bounded superiorly by the mandible, posteriorly by the anterior border of the sternomastoid and separated from the opposite anterior triangle by an imaginary median line. The posterior triangle is bounded anteriorly by the posterior border of the sternomastoid, posteriorly by the anterior border of the trapezius and inferiorly by the midsection of the clavicle. It should be especially noted that while the upper part of the posterior triangle is in the posterior portion of the neck, the midpart is in the lateral area and the lower part extends even to the anterior portion of the neck.

The nerve supply enters the deep surface of the upper half of the sternomastoid and comes roundabout from the upper cervical segments. A part of this nerve continues vertically downward across the posterior triangle to enter the trapezius muscle.

The sternomastoid should be cleared by dissecting off the superficial part of its deep fascia.

Depressors of Hyoid Bone.

As a matter of ordinary observation it may be noted that the hyoid bone, together with the thyroid and cricoid cartilages, moves up and down during the process of swallowing. The muscles having the power of pulling down the hyoid bone are known as the depressors, while those raising it up are known as the elevators. The superficial group of the depressors are the **sternohyoid** and the **omohyoid** (omo = shoulder). The sternohyoid runs vertically upwards from the back of the sternum, while the omohyoid runs from the scapular notch of the superior scapular margin diagonally upwards and forwards to its insertion into the hyoid bone. The deep group is made up of what is practically one sheet, which inserts into the thyroid cartilage and then another section arises to run up to the hyoid, the sections of this muscle being named the **sterno-thyroid** and the **thyrohyoid**. All these muscles are flat band-like sheets.

Elevators of Hyoid

The **digastric** or two bellied muscle arises anteriorly from the deep surface of the mandible near the midline and posteriorly from under the mastoid process, running to a common tendon which is held by a pulley arrangement to the hyoid bone. The **mylohyoid** arises from the hyoid bone and inserts into a ridge around the middle of the inside of the mandible, forming a diaphragm muscle across the floor of the mouth. The geniohyoid and the stylohyoid are also elevators, but these lie deeper and therefore will not be considered until a later stage of the dissection (genio = chin).

These elevator and depressor muscles receive their nerve supply from the cervical plexus, but also receive branches from the twelfth cranial or hypoglossal nerve. These muscles have not only the power of raising and depressing the hyoid bone, but if they all contract at the same time, work at mechanical advantage in depressing the mandible. Further, if the mandible were held closed by its muscles, these muscles would then on contraction flex the head and neck.

Minor Triangles

The digastric and the omohyoid muscles are used to subdivide the large anterior triangle into three minor triangles. The minor triangle, marked off by the bellies of the digastric muscle and the mandible, is known as the **digastric**. The triangle between the omo-

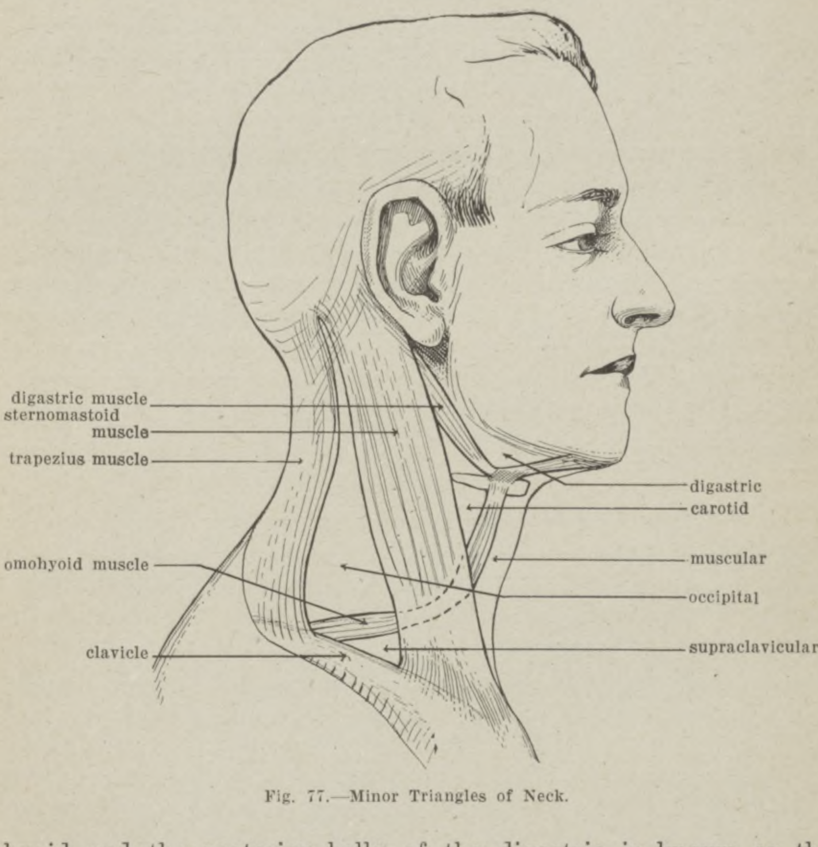


Fig. 77.—Minor Triangles of Neck.

hyoid and the posterior belly of the digastric is known as the **carotid,** because just back of this area the common carotid artery terminates in its external and internal branches. The remaining triangular area is fairly well covered by the sternohyoid muscle and hence is called the **muscular** triangle.

The omohyoid subdivides the large posterior triangle into two smaller minor triangles. The small area below the omohyoid, posterior to the sternomastoid and above the clavicle should be known as the **supraclavicular** triangle, while the remaining large area of the posterior triangle is known as the **occipital** triangle.

The elevator and depressor muscles of the hyoid bone should be cleared sufficiently to demonstrate the minor triangles. Then the sternohyoid and the omohyoid muscles should be divided in order to demonstrate the deeper layer, that is, the sternothyroid and the thyrohyoid muscles.

Deep Venous System

The **internal jugular vein** lies just under the sternomastoid muscle, the common carotid artery lying deep to the vein, and the vagus nerve between the two. The jugular vein is joined by the subclavian in the lower part of the neck, slightly above the first costosternal articulation. On the left side the main lymphatic duct of the body empties into the left subclavian near its junction with the jugular, while on the right side the corresponding lymphatic duct drains only its own thoracic and neck regions. The left lymphatic duct, over one-eighth of an inch in diameter when distended, is distinguishable from a vein on account of color, but this is as previously noted untrustworthy in the dissecting room. The left jugulosubclavian, or innominate, vein runs across under the upper part of the sternum to join the right jugulosubclavian or innominate, making up the superior vena cava (Innominate=BNA anonyma). Along the jugular vein and its branches lie the main group of lymphatic glands of the neck.

Dissection.—In order to demonstrate the deep venous system, the origins of the sternomastoid muscle from the upper part of the sternum and from the sternal third of the clavicle should be cut across. Then the sternomastoid muscle should be dissected out of its deep fascia sheath up to its attachment to the mastoid process. This step exposes the internal jugular vein practically throughout its course. In order to expose the subclavian and innominate veins it is necessary to remove the remaining parts of the sternum and clavicles, which can best be done by sectioning the first pair of costal cartilages near their junction with the sternum. The sternoclavicular joints with their limited range of motion should be noted, but the joints should not be opened until later, as it is important to be able to replace this sternoclavicular segment from time to time in order to keep clear its relation to the deeper structures.

Scalene Muscles

The scalene group of muscles should now be noted running from the transverse processes of all the cervical vertebræ to the first and second ribs. The **scalenus anterior** raises up a tubercle on the first rib and separates the subclavian vein, which runs in front, from the subclavian artery, which runs behind this muscle. Through the space between the scalenus anterior and the scalenus medius also emerge the cervical nerves, the upper four making up the cervical plexus, the lower four and first thoracic the much larger brachial plexus. The phrenic nerve arises from the fourth cervical nerve and crosses the anterior surface of the scalenus anterior from the lateral side medially en route to the mediastinum, from which place its further course to the diaphragm has been traced. The **scalenus medius** and **posterior** insert into the first and second ribs at the lateral parts of their circumference. These muscles would obviously act as a costal respiratory group and eventually determine the height at which the whole thorax stands. It should be noted again that the apices of the pleural cavities dome up an inch or more into the base of the neck.

These muscles should be cleared sufficiently to bring out the points noted.

Arteries.

The subclavian artery through branches supplies the lower part of the neck, the upper part of the chest and sends a branch into the interior of the skull. The common carotid artery through its branches supplies the upper part of the neck and carries the preponderant bulk of the supply to the head. On the right side the innominate artery runs well up into the base of the neck before dividing into its separate common carotid and subclavian subdivisions, while on the left side the common carotid and subclavian enter the base of the neck as separate vessels.

The innominate (anonyma) and the left common carotid and left subclavian arteries should be cleared to their origin from the arch of the aorta.

Branches of Subclavian

The branches of the subclavian artery are subject to many variations, coming off sometimes separately, or sometimes several vessels sprout out of a short axis stem. It will be more convenient to consider the branches according to the field they supply and to disregard their varying origins from the subclavian. The **internal mammary** runs downward in back of the costal cartilages near the sternum, its diaphragmatic and epigastric branches having been previously traced to their terminations. The **costocervical** trunk runs down to supply the upper three intercostal spaces and anastomoses with the aortic intercostal vessels of the fourth space. The **vertebral** runs upward through the foramina in the transverse processes of the upper six cervical vertebræ and then enters the interior of the skull. The **transversa colli** runs transversely around the neck to supply the various muscles of the lateral lower half of the region (collum=official name for neck). The **transversa scapulæ** runs on a lower level than the transversa colli, terminating in the musculature of the scapula. The **inferior thyroid** runs medially in back of the common carotid artery to its termination in the lower half of the thyroid gland.

The branches of the subclavian artery should be cleared and traced out, disregarding the corresponding veins.

Branches of External Carotid

The common carotid artery travels up under the sternomastoid muscles without giving off branches, to its termination just posterior to the hyoid bone in the external and internal carotids. The external carotid at first lies just in front of the internal and is therefore not named on account of its primary relationship, but because it supplies the exterior of the skull. The internal carotid goes through the base of the skull without giving off branches and aided by the vertebral artery supplies the brain. The branches of the external carotid are fairly regular and are named according to their distribution. The **superior thyroid** runs down to the upper half of the thyroid gland, incidentally supplying the larynx. The **lingual** immediately buries itself in the group of muscles at the base of the tongue. The **external maxillary** or facial runs across the external surface of the lower jaw, crossing the face diagonally on its course to the medial angle of the eye. The **internal maxillary** is a large vessel, which as its name implies travels inside of the lower jaw and supplies this important area. The superficial **temporal,** or anterior auricular, runs up just in front of the ear to supply the temple region, while the **posterior auricular** supplies the scalp in back of the ear. The **occipital** supplies the scalp over the back of the skull, that is, the occipital region. The ascending **pharyngeal**

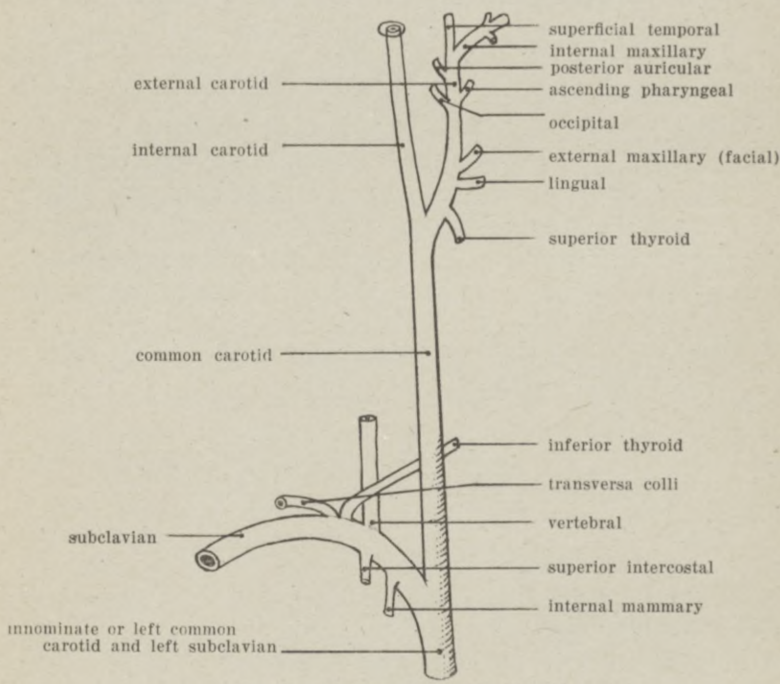


Fig. 78.—Diagram of Arteries of Neck.

is a small inwardly directed branch, which helps to supply the pharynx region.

The branches of the external carotid should be cleared in the neck, but the tracing out to their distributions must be postponed until a later stage of the dissection.

Nerves of Neck

The presence of the ninth, tenth, eleventh and twelfth pairs of cranial nerves complicates the supply of the neck (cranium =

skull). These cranial nerves (nervi cerebrales) leave the interior of the skull through bony canals very deep in from the surface of the neck. The ninth, tenth, and eleventh nerves go through the same opening as the internal jugular vein, while the twelfth goes through a neighboring separate opening. These nerves, together with the cervical sympathetic, form a plexus just after emerging from the interior of the skull. In the deep dissection these nerves can be identified by their location and directions. The ninth, or **glossopharyngeal,** is the special sensory nerve of taste, which breaks up into small branches and goes forward closely applied to the pharynx to the root of the tongue. The **tenth, or vagus,** sends motor branches to the pharynx, motor and sensory branches to the larynx, and has been considered in its further course through the neck and mediastinum. The vagus is extra large in the neck as it carries processes from these other cranial nerves en route towards their termination. The **eleventh, or accessory,** runs straight down to supply the sternomastoid and continues vertically downward across the posterior triangle to the trapezius muscle. The **twelfth, or hypoglossal,** turns around superficially to the branches of the external carotid artery and runs forward to supply the group of muscles under the tongue. As has been previously noted, this nerve sends part of the supply to the muscles controlling the hyoid bone.

As noted in connection with the scalene muscles, the upper four cervical segmental nerves make up the small **cervical plexus,** while the lower four cervical and the first thoracic make up the very large **brachial plexus.** The phrenic nerve, which arises from the fourth cervical segmental, has previously been considered as it crosses over the anterior surface of the scalenus anterior muscle en route to the mediastinum. Theoretically we would expect to find eight ganglia of the sympathetic trunks, as there is commonly a sympathetic ganglia for each segment. As a matter of fact the upper four ganglia are fused into the superior cervical ganglia, the next two into the middle cervical ganglia and the lower two into the inferior cervical ganglia. The superior cervical ganglia not only controls the involuntary activities of the upper part of the neck, but also as will be detailed later, a considerable portion of the involuntary functions of the head. The sympathetic gangliated trunks lie at the junction of the bodies of the vertebræ with the roots of the vertebral arches.

These nerves should be located and cleared as much as possible without disturbing unknown structures. The sternoclavicular segment should be replaced in position in order to demonstrate the course of the brachial nerve plexus and the subclavian artery under the midsection of the clavicle and over the first rib.

Thyroid Gland (Glandula Thyreoidea)

The thyroid gland at an early stage of development has a duct which leads vertically upwards to the superior surface of the root of the tongue (thyroid = shield-shaped). This duct does not functionate after a certain stage of fetal development, but disappears, leaving the thyroid a ductless gland. Abnormally remains of the mucous membrane of this thyroglossal duct may lead to the formation of cystic tumors in the median line. The thyroid is composed of two lateral lobes, which lie closely applied to each side of the trachea, and an isthmus which forms a connecting strand between the lobes. The isthmus crosses the rings of the trachea normally about one-quarter of an inch below the cricoid cartilage, but abnormally the whole gland may sag down, when enlarged even projecting into the mediastinum. The whole gland is surrounded by a capsule, which is firmly held by ligaments and fascias to the trachea. The lateral lobes are considerably larger than the isthmus, extending up alongside the cricoid cartilage and inferiorly being completely covered by the sternomastoid muscles. The height of the thyroid gland above the sternum varies with the relative standing of the chest, but on account of its attachment to the trachea the gland is always raised up when the head is fully extended.

Microscopically the gland is made of acinus nests, which are lined by a single layer of flat epithelial cells and filled with a varying amount of gelatinous-like, or colloid, secretion. The superior thyroid arteries are branches of the external carotid, while the inferior thyroid arteries come from the subclavian. A varying number of small nodules, commonly about six, which lie in the thyroid gland or in the posterior portion of its capsule are called **parathyroids.** While not the same thing, these parathyroids are anatomically and probably functionally closely related to the thyroid gland.

It is definitely known that some secretion from the thyroid gland is required to keep the body in health. Clinically certain symptoms are recognized as due to too little and others as due to too great activity of this gland, technically hypo- and hyperthyroidism. General enlargement of the thyroid gland, involving both lateral lobes and the isthmus, is popularly known as goiter.

The inferior laryngeal nerves ascend to the larynx, coursing about at the junction of the trachea with the esophagus. After splitting the isthmus and dissecting the thyroid from the trachea these nerves should be traced through to the larynx. The thyroid gland should be examined in place, and then removed and cross-sectioned.

Pharynx

The pharynx is a combination respiratory and alimentary tube, which in man persists as such throughout life. Air passes back and forth from the nose to the larynx via the pharynx, while food and drink are forced from the back of the mouth through the pharynx to the esophagus. The respiratory portion of the pharynx is held permanently open, while the walls of the part nearest the esophagus come in contact when not in use. The pharynx as a matter of convenience is divided into three parts; a superior nasopharynx, a middle oropharynx, and an inferior laryngopharynx. Through the mouth the posterior wall of the oropharynx can be seen directly, but the naso- and laryngo-pharynx are only indirectly visible via mirror reflections. The walls of the pharynx are composed of the usual mucosa, submucosa, and muscle layers, which have their ordinary characteristics. The mucosa as in the mouth and esophagus is lined by epithelium of the stratified squamous type and later on will be noted to contain aggregations of lymphatic tissue. The submucosa is a very tough, fibrous layer, which eventually must be incised in order to relieve extrapharyngeal abscesses. The superior, middle and inferior constrictor muscles of the pharynx are very thin sheets, which arise from the mandible, the hyoid bone and the thyroid cartilage, respectively, and encircle the pharynx. The middle constrictor overlaps the superior and the inferior constrictor overlaps the middle, so that, practically speaking, the whole pharynx is covered by crossing muscle sheets. The stylopharyngeus muscle runs from the long tip of the styloid process of the base of the skull to its insertion into the lateral pharyngeal wall. The nerve supply to the pharanyx comes from the vagus and glossopharyngeal nerves, and is of the voluntary type. It should be especially noted that the common carotid arteries lie just lateral to the lateral pharyngeal wall, while the internal and external carotid arteries are separated from the lateral pharyngeal wall by a distance not greater than half an inch. This distance, however, is ordinarily increased when an abscess bulges into the pharynx.

The constrictor muscles should be cleared, and then the posterior pharyngeal wall separated by blunt dissection from the anterior surfaces of the cervical vertebræ. The submucosa layer of the pharynx should be incised freely along the midposterior line in order to demonstrate its relative strength.

Gills and Gill-Clefts

The fish group of vertebrates have commonly six pairs of gills, which serve as the respiratory apparatus, or in other words which bring about the interchange of carbon dioxide and oxygen. The number of clefts between the gills varies among the different types of fish, but is commonly either five or seven. These gill clefts run through from the external surface of the neck region into the pharynx, allowing water to circulate freely about the gills. The framework of the gills is made up of cartilage, while the functionally essential part is a rich network of capillary vessels, which are covered by a modified mucous membrane. The fish's heart pumps venous blood into a ventral aorta, which then passes via the series of gill arteries and capillaries into a dorsal aorta. This dorsal aorta during the life contains arterial blood, which is distributed via segmentally arranged branches throughout the body, and after passing through the systemic capillaries returns as venous blood to the heart. In the neighborhood of the gill clefts the ventral and dorsal aortas are represented in some types of fish by a single vessel, in most types, however, they are made up of paired vessels. The gills and their arterial arches, as a matter of arbitrary convention, are numbered in sequence from the head toward the tail.

Now the human embryo develops six pairs of gills and four pairs of modified clefts, although it is obvious they are purely vestigial structures and never functionate. The modification of the clefts consists in the fact that they do not open through from the neck into the pharynx, but are represented by opposing grooves in the neck and pharynx, separated by a thin septum of mucous membrane. The cartilaginous framework of the first gill persists as the basis for the mandible, as also occurs in many fishes, while the framework of the second persists as the hyoid bone. The ascending thoracic aorta in the human represents the ventral aorta of the fish, the arch of the aorta represents the left fourth gill artery, while the descending thoracic aorta represents the dorsal aorta. Further the pulmonary aorta is a part secondarily separated from the original ventral aorta, while the pulmonary arteries represent the sixth gill arterial arches.

The clinical occurrence of various types of cartilaginous and mucous membrane tumors in the lateral mandibular and neck regions is explained as due to the abnormal persistence of parts of these embryonic gills.

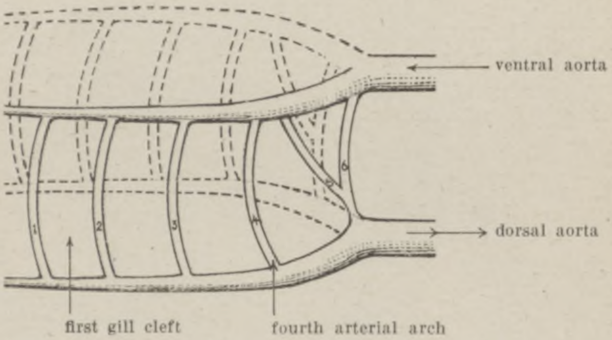


Fig. 79.—Diagram of human gill arterial arches.

Larynx

The larynx functionates as the beginning of the tracheobronchial system and as the special organ of speech. The framework of the larynx is made up essentially by the thyroid and the cricoid cartilages. The thyröid cartilage is suspended from the hyoid bone by thyrohyoid muscles, ligaments, and a membrane. The cricoid cartilage is attached to the thyroid by a pair of cricothyroid joints, muscles, ligaments, and a membrane. The **epiglottis** is a thin sheet of elastic fibrocartilage, which projects up at the back of the tongue, and is attached by ligaments essentially to the thyroid cartilage, but has other minor musculoligamentous attachments to the tongue, hyoid bone, and arytenoid cartilages (glottis = essential voice apparatus). The pair of **arytenoid cartilages** ride on the upper part of the signet surface of the cricoid and are most important structures inasmuch as the vocal ligaments, that is, the true vocal cords are attached to them.

Two nerves leave the vagus trunk to supply the larynx. The **superior laryngeal nerves** follow the superior thyroid arteries, carrying the supply to the upper half of the larynx. The **inferior laryngeal nerves** have previously been noted to follow down in the

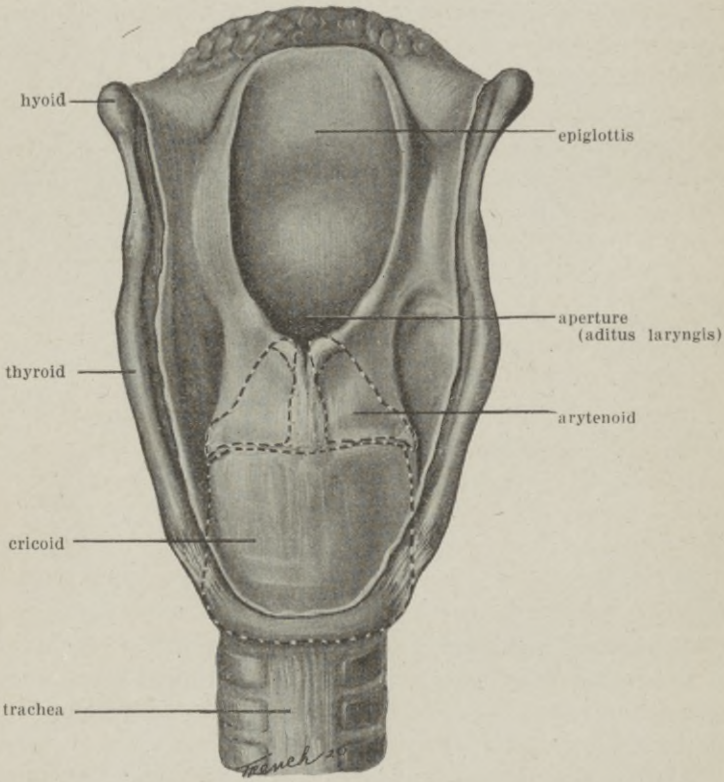


Fig. 80.—Posterior view of **Larynx**, showing arytenoid and cricoid cartilages projected to surface by dotted lines.

vagus nerve into the mediastinum, and then holding a course between the trachea and esophagus to return to the larynx. As the inferior are the main motor nerves to the larynx it follows obviously that mediastinal disease may manifest itself by a disturbance of or loss of speech.

After examining the larynx in position, the thyrohyoid muscles and ligaments should be sectioned, and the musculoligamentous connections between the epiglottis and the root of the tongue and between the epiglottis and the hyoid bone should be cut across at a convenient midpoint. Then the trachea and esophagus should be divided about an inch below the cricoid cartilage, which dissection frees the larynx so that it may be removed for detailed examination. It should be especially noted that the cartilaginous semi-rings of the trachea are deficient posteriorly, where the trachea comes in contact with the vertebræ.

When the larynx has been removed from the body, the size and shape of the thyroid and cricoid cartilages, and of the epiglottis and arytenoid cartilages can be reviewed to great advantage. It should now be noted that the cavity of the larynx is materially smaller than would appear from an external examination of the parts while in position, due to the fact that the thyroid cartilage forms not only the lateral walls of the larynx, but also protects the lateral walls of the laryngopharynx.

Aperture of Larynx (Aditus Laryngis)

The aperture of the larynx is the opening in the anterior wall of the laryngopharynx through which air passes from the laryngopharynx into the larynx. The plane of this opening is not vertically arranged, but slants distinctly downward-backward from the epiglottis to the apices of the arytenoid cartilages. The size of this opening varies materially as it is surrounded by what amounts to a sphincter muscle. The muscles in the free margins of these folds are known as the aryepiglottic, as they run from the arytenoid cartilages to the epiglottis. Two little cartilages in each aryepiglottic fold are of the sesamoid type and are known technically as the cartilago cuneiformis and the cartilago corniculata.

In contradistinction to former beliefs, it is now recognized that the epiglottis maintains its upright standing position at the back of the tongue even during swallowing, that is, it does not bend back to close the aperture of the larynx. During swallowing the aryepiglottic muscles draw the arytenoid cartilages up to the posterior surface of the base of the epiglottis, thus practically closing the aperture, while the epiglottis itself prevents liquids from trickling into the less firmly closed anterior portion of the aperture.

The mucous membrane should be split along the aryepiglottic fold and dissected back, thus exposing the muscles, ligaments and miniature cartilages noted in the preceding discussion.

Vocal Folds (Plicæ Vocales)

If now the aperture of the larynx be spread open, by looking through the larynx two pairs of folds can be noted along the side walls. These ridges are raised up by muscles and ligaments, the upper pair being the **plicæ ventriculares**, or false vocal cords, the lower pair the **plicæ vocales** or true vocal cords. The ventricular folds are simply low ridges, which are raised up by muscle fibers covered by mucous membrane and are not concerned with the production of the voice sound. These folds are used as a line of demarcation between the upper part or vestibule and the middle compartment of the larynx. The vocal folds attach to the back surface of the thyroid cartilage just below the laryngeal prominence and run to the vocal processes of the arytenoid cartilages. These vocal folds are made up by the vocal muscle and ligament, covered by a very much thinned out mucous membrane, this combination of structures being technically known as the vocal lip (labium vocale). This ligament is made up of white fibrous tissue and normally during life shows up as dense white against the pink background of the normal mucosa.

The vocal folds during the activity of speaking are drawn tense and practically together by muscular action on the arytenoid cartilages, but otherwise the muscles are relaxed and the folds separate widely. This tightening of the vocal folds is also aided by cricothyroid muscles, which change the relationship of the cricoid and thyroid cartilages. Air forced rapidly through the narrow slit produces the voice sound, which is variously modified as will be noted in connection with the detailed study of the nose, mouth, tongue, and lips. The vocal folds of the female are characteristically about one-quarter shorter than those of the male, which anatomical fact accounts for the differences in pitch of the voices. Very high notes call for extreme muscular exertion, while very low notes call for relaxation with control, consequently these extremes are the hardest to acquire and to keep. If one vocal lip is incapacitated or its musculature destroyed or nonfunctionating, the laryngeal note can not be produced, but whispering, which is brought about by the use of the tongue, teeth and lips, is not interfered with.

Dissection.—The cricothyroid membrane, which is partly covered by a muscle of the same name, now deserves more detailed attention. Then by manipulating the thyroid and cricoid cartilages the pair of joints can readily be made out. By removing the mucosa and submucosa from over the large posterior surface of the cricoid cartilage, the pair of cricoarytenoid posterior muscles may be completely exposed. By carrying the dissection of the mucosa and submucosa upward, the arytenoid cartilages and the cricoarytenoid joints may be exposed. The oblique and transverse arytenoid muscles, running between the medial posterior surfaces of the arytenoid cartilages, steady the pivoting of these cartilages during tightening of the vocal ligaments. The insertion of the cricoarytenoid and thyroarytenoid muscles raise up a processus muscularis on the lateral dorsal point of the arytenoid cartilages. The medial ventral point of the arytenoid cartilages is known as the processus vocalis on account of the attachment of the vocal ligament. Then the attachment of the base of the epiglottis to the superior margin of the thyroid cartilage should be reviewed. Finally an incision in the anterior median line should be carried through the epiglottis and the thyroid and cricoid cartilages and trachea. By spreading this incision the whole interior of the larynx may be freely exposed to view. The epithelial covering of the mucosa of the laryngeal cavity above the vocal folds is of the stratified squamous type, while that below these folds is like the trachea of a stratified columnar type. After the ventricular and vocal folds have been examined, the mucosa and submucosa may be removed from the whole interior of the larynx. Groups of muscles may be recognized in a general way, but the full detail is too complicated for our present purpose.

Practical

Spasmodic contraction of the laryngeal muscles, known popularly as spasmodic croup, may produce a serious appearing condition, but after a certain stage of blueness has been reached, the muscles relax. This disease is closely related to asthma. If a foreign body by accident slips through the larynx into the trachea, the musculature of the vocal folds goes into spasm and commonly prevents expulsion. If the patient be held up by the heels, the action of gravity will cause the foreign body to rest against the contracted vocal folds, and if these folds relax on account of the pressing demand of the body for oxygen, the foreign body may fall out into the pharynx. Any great surprise, as for example a sudden slap across the back, may cause relaxation of the laryngeal spasm and thus aid in expulsion. If the foreign body remains in the trachea, it commonly lodges in the right primary bronchus or one of its lower subdivisions, on account of greater size and more favorable directions. These foreign bodies tend to cause irregular attacks of pneumonia in the lower lobe of the right lung, and after months or years tend to become firmly embedded in their position. If the emergency measures noted fail to cause expulsion of the foreign body, a special tube with forceps arrangement must be passed through the larynx, or a tracheotomy must be performed in order to remove the foreign body. The usual tracheotomy is performed above the isthmus of the thyroid gland, and may or may not be continued through the ring of the cricoid. If the surgeon remains strictly in the middle line, the performance of a tracheotomy or laryngotomy is a very simple operation, comparatively free from operative risk. Diphtheria of the larynx, which is popularly known as membranous croup, or any severe laryngeal disease, may mechanically shut off the air supply and call urgently for a tracheotomy.

Craniovertebral Joints

The first cervical vertebra is very much modified from the type plan of the other cervical vertebræ and is known as the atlas (atlas = support). The range of flexion and extension motion between the transverse processes of the atlas and the base of the skull is materially greater than between any other vertebræ. The second cervical vertebra is known as the epistropheus (O.T. axis), due to the fact that rotation between this bone and the atlas is materially greater than between any other vertebræ (stropheus = turning). These vertebræ are modified anatomically so as to be fitted for these special functions. The anterior and the posterior longitudinal ligaments and the ligamenta flava are carried up practically unmodified to their connections with the base of the skull.

Occipital Bone

The atlas articulates with the neck surface of the occipital bone of the skull. The large opening in the occipital bone through which the spinal cord enters the interior of the skull is known as the **foramen magnum.** On each side of the anterior portion of this foramen lie the condyles, which are convex rocker surfaces for articulation with the concave surfaces of the transverse processes of the atlas. The anterior and posterior longitudinal ligaments attach to the anterior half of the foramen magnum, while the ligamenta flava attach to the posterior half. The coming together of the anterior and posterior longitudinal ligaments is due to the fact that the first cervical vertebra lacks a body.

Atlas

The characteristic feature of the atlas is that it has no body, while another feature is that the transverse processes extend out

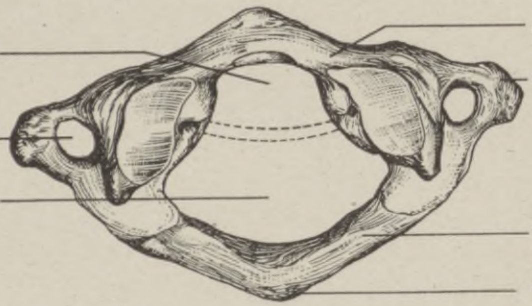


Fig. 81.—Superior surface of **Atlas**, the first cervical vertebra.

materially further than those of the other cervical vertebræ. A process from the epistropheus, known as the **dens,** projects upward, usurping the place of the body of the atlas (dens, O.T. odontoid = tooth). This process acts as a pivot around which the greatly increased rotation between the atlas and epistropheus is permitted. An anterior arch of the atlas in front and a transverse ligament behind form the socket for this dens process. The ligaments as in other joint regions act as checks against excessive range of mobility. The vertebral arteries after passing through the transverse foramina of the upper six cervical vertebræ pierce the ligamenta flava en route to the interior of the skull.

Epistropheus

The epistropheus is an especially strong vertebræ with an extra long spinous process. The **dens** projects upwards from the body of the epistropheus into the socket formed for it by the atlas and is attached by a ligament to the front of the foramen magnum. The transverse process articular surfaces of the epistropheus meet the opposing articular surfaces of the atlas on practically a horizontal plane. These surfaces are extra large and allow an exceptionally wide range of lateral movement, as compared with the transverse joint surfaces of the rest of the vertebral column.

Severe injury to the spinal cord in the region of these joints is rapidly fatal because respiration is completely stopped, both of the costal and of the diaphragmatic types. Scientific hanging consists in breaking or dislocating the upper cervical vertebræ by the sudden checking up of the body weight during rapid fall. Amateur hanging usually is performed without a proper fall and is an inhuman system of strangling.

Muscles

The motions noted in connection with these joints are obviously controlled to a great extent by various muscles of the neck previously considered, as for example, by the splenius, semispinalis and sternomastoid muscles. But the deep group of muscles, which arise from the upper cervical vertebræ and insert into the base of the skull around the foramen magnum are specialists in causing these movements. Two paired muscles of this group in back of the upper cervical vertebræ, belonging to the extensor capitis group, are known as the rectus capitis posterior, major and minor. Two paired muscles in front of the cervical vertebræ, belonging to the flexor capitis group, are known as the rectus capitis anterior and the longus capitis. Two paired muscles, which arise from the transverse processes of the atlas and insert into the occipital bone, thus having a varying and complicated action, are known as the rectus lateralis and the obliquus capitis superior.

Dissection.—The flexor and extensor capitis muscles may be readily demonstrated and then divided near the base of the skull. After dividing these muscles the anterior and posterior longitudinal ligaments and the ligamenta flava may be exposed by blunt dissection and then divided. The knife should then be plunged in from both in front and back, dividing the dura mater and spinal cord. On account of the lateral extent of the transverse processes of the atlas, and their proximity to the base of the skull, it is very difficult to demonstrate the lateral capitis muscles and the occipito-atlas joints. By forcing the cervical vertebræ strongly to one side, however, it is possible to cut and break through these ligaments and joints. The points noted in the discussion should then be reviewed.

CHAPTER XIII

THE HEAD

SKULL PROPER

Cranium Cerebrale

The bony framework of the head is known as the cranium, or skull, which is subdivided into a part that forms a box for the protection of the brain (cranium cerebrale), and a part that makes the bony framework of the face (cranium viscerale). In the fetus and until the skull has reached its adult size at about fourteen years of age, the bony skeleton is made up of a large number of distinctly separate bones. The cartilage lines decrease in width as development proceeds and in the adult the bones of the skull with the exception of the mandible, become fused into practically one solid piece. Because the cartilage of the **suture** lines does not disappear at the end of the growth period, but persists throughout life, the various parts of the skull are considered as separate bones (suture = sew). The suture lines are very irregular, the projecting parts of one bone being deeply set into depressions of the opposing bone. The suture lines make practically immovable joints, technically of the synarthroidal type, which functionate by yielding extra elasticity. A peculiarity of the bony development of the skull is that the cartilage about the vault of the skull first turns into fibrocartilage before any bone is deposited. This is known as the intramembranous type of bone development, the only peculiarity being, as previously noted, the appearance of the connective-tissue framework before any lime salts are deposited. The very early appearance of the fibrous tissue in the cartilage of the vault of the skull is probably to be explained as a protection to this important area.

The cranium cerebrale is described as being made up of a **calvaria,** or vault, and a **base,** or floor. The calvaria forms the well rounded dome-shaped portion which extends up from the base encasing the brain. The rounded surfaces of the calvaria take advantage of the arch principle, which serves to increase its strength. The base is very irregular due to the cervical muscle attachments, and is further characterized by a number of openings, which allow the spinal cord and numerous arteries, veins and nerves entrance or exit. The consideration of the cranium viscerale, which is very irregular on account of the requirements of the eyes, nose, and mouth, will be postponed until the face is taken up in detail.

Landmarks

The muscle-aponeurosis covering of the calvaria is relatively thin, consequently the bones are readily palpable throughout as landmarks. The prominent **supraorbital margins** are used to separate the forehead region of the calvaria from the eye socket (orbita = globular socket). The **zygomatic arch,** which extends from just in front of the ear to the cheekbone, separates the temple region of the calvaria from the side of the face. The mastoid process, the external occipital protuberance and the curved line between these landmarks separate the calvaria from the base of the skull. All these points, being superficial, are readily to be made out.

Development of Skull

The skull is primarily laid down in cartilage, but by the time of birth ossification has spread so far that only spaces of about one-quarter of an inch between the neighboring sections are still filled by cartilage. The **frontal bone** forms the forehead and extends backward over the brain almost two inches beyond the normal hairline (frons = forehead). On a level with the supraorbital margin, the frontal bone sends a thin plate backward to separate the top of the eyes and nose cavities from the interior of the skull. At birth this bone is made up of two halves separated by cartilage, but these parts unite so early in life that the adult bone shows no trace of this division. The **parietal bones** form great sections of the calvaria, but do not reach laterally down to the base. The two marked projections on the posterior portion of these bones, marking the widest measurement of the skull, are known as the parietal tubers. A portion of the greater wings of the **sphenoid bone** takes part in the formation of the lateral skull wall between the frontal, parietal and temporal bones. The sphenoid bone also takes part in the formation of the base of the skull, separating the brain from the nasopharynx and the internal maxillary regions (sphenoid = wedge). The squamous plates of the **temporal bones** bevel onto the opposing outer surfaces of the parietal bones. The temporal bone contains the ear, and

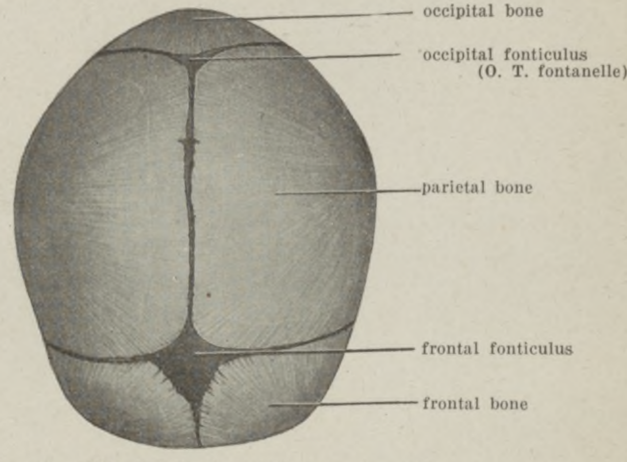


Fig. 82.—**Skull (Cranium)** at birth, superior view.

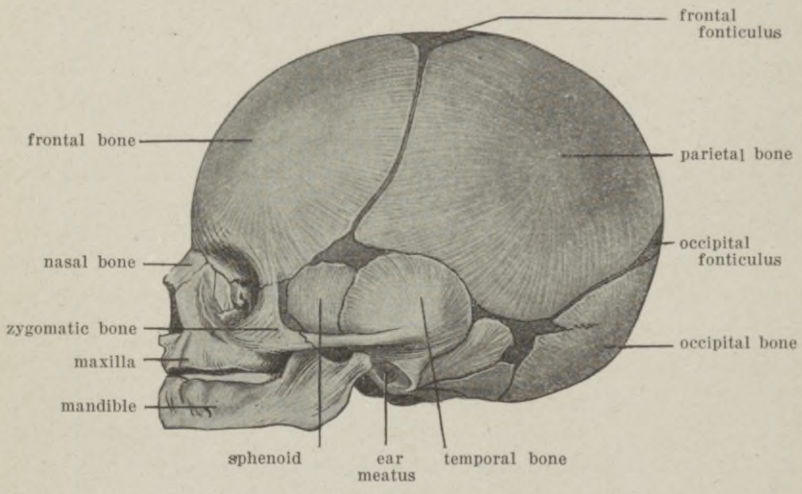


Fig. 83.—**Skull (Cranium)** at birth, lateral view.

aside from its squamous plate, zygomatic process, and mastoid process already noted, takes part in the formation of the base of the skull. The junction of the **occipital bone** with the parietals leaves a permanent irregularity, which can be felt in the middle line about two and a half inches above the external occipital protuberance. The occipital bone turns forward inferiorly, forming, as previously noted, a large section of the base of the skull.

The skulls of the European races are markedly larger anteroposteriorly than from side to side, whereas the skulls of the Asiatic races approach nearer to roundness.

Suturæ et Fonticuli

The cartilage strips allow the cranial bone to overlap during the birth process, normally without injury to the cranial contents. The width of these cartilage strips decreases markedly as growth progresses, and eventually white fibrous tissue grows through the cartilage, yielding strength to the joint. The opposing bone surfaces are markedly irregular, and are tongued and grooved so that in spite of a small permanent residue of cartilage the skull is practically one solid piece. The suture lines in the adult are fully as strong as the other parts of the skull, as may be noted in connection with fractures. The suture lines, though often given special names, are logically named according to the bones or parts of bones separated, as for example the left fronto-parietal suture line is between the frontal and left parietal bone, and so forth.

As an exception to this rule the suture line between the two parietal bones is known as the **sagittal** suture, while the line between the right and left parietals and the frontal bone is known as the **coronal** suture. The reason for this variation in nomenclature is that whereas horizontal planes at a fixed level are always definite, vertical planes may vary throughout the whole range of the compass. The vertical planes, which parallel the interparietal suture are therefore known as sagittal planes, whereas those which parallel the fronto-parietal suture are known as frontal, or coronal, planes.

A large space in the newborn child is covered only by cartilage at the junction of the midfrontal, midparietal and the right and left frontoparietal suture lines. This is known as the **frontal** or major **fonticulus**, for here during the first year of life the normal pulsations of the brain may readily be felt (fonticulus, or O.T. fontanelle = diminutive of fountain). This pulsation is produced by the arterial pulse wave, exaggerated at this point because the remainder of the brain is held in a relatively unyielding box. The right and left occipito-parietal and mid-parietal suture lines at their junction form the smaller **occipital** or minor **fonticulus.** The large frontal fonticulus is the last cartilage area to be converted into bone, but even that is normally changed by the end of the first year of the child's life.

Scalp

The skin, subcutaneous fatty layer, deep fascia, and a musculo-aponeurotic layer are blended into one sheet over the calvaria, which is known as the scalp. The scalp, as a matter of common knowledge, is freely movable over the skull to a fixed limit and can be controlled by voluntary musculature. The skin is characterized by the great abundance of hair, except over the forehead region, which, although popularly considered a part of the face, is anatomically a part of the scalp. The fatty layer is characterized by its extreme toughness, and, further, it is interesting to note that the amount of fat in its meshes does not increase in general stoutness of the individual. The **epicranial** muscle and aponeurosis is spread out over the whole calvaria, the deep fascias being blended with this layer (O.T. occipitofrontalis). The small occipital muscle bellies arise from near the curved line posteriorly, while the frontal bellies arise from the supraorbital margins.

Vessels and Nerves

A notch can be palpated along the eye surface of the supraorbital margin between its intermediate and medial thirds. This is known as the supraorbital notch, and exists for the passage of the **supraorbital** branch of the fifth cranial nerve, accompanied by a small artery and vein. This nerve supplies the frontal part of the scalp, and, as it is exclusively sensory, is at times pressed on by an examiner in order to determine the depth of unconsciousness in an unconscious person. Crossing over the root of the zygomatic process just in front of the ear, run the **superficial temporal** or anterior auricular artery, vein, and nerve. This largest artery of the scalp is a branch of the external carotid, while the nerve comes from the interior of the skull and is purely sensory. This artery, vein, and nerve supply the lateral or temple part of the scalp. A short distance behind the ear run the **posterior auricular** artery, vein, and nerve, while nearer the posterior midline are to be found the larger

occipital artery, vein, and nerve. These nerves are peculiarly sensory branches from the cervical plexus, while the arteries are branches of the external carotids.

The vessels of the scalp bleed profusely and persistently when cut. The anatomic explanation offered is that the tough connective tissues do not allow the vessels, when cut, to retract and curl up as in other regions of the body. As no forceps yet devised hold this layer really satisfactorily, hemorrhage is ordinarily best controlled by pressure. The normal beginnings of baldness at points furthest removed from the main vessels points to a nourishment factor in this common ailment.

Dissection.—After locating these various arteries, veins, and nerves at their entrance into the scalp and tracing them along their course for a limited distance, the scalp should be split from one mastoid process to the other and from the external occipital protuberance to the root of the nose. The cross section should be studied and then the scalp pulled down to the face and neck bony landmarks. The epicranial muscle bellies and further detail in regard to the blood and nerve supply of the scalp may then readily be made out. The subscalp layer should be noted to be made up, exclusively of white fibrous tissue, and to allow a limited range of motion. The loose texture of this layer allows abscesses to spread out under the whole scalp, while the various forms of scalping take place through this line of lesser resistance. It should be noted that the scalp flaps carry their own vessel and nerve supply, when torn loose from the calvaria. Periosteum still covers the cranial bones and should be scraped off to examine the suture lines between the various bones. Then a saw-cut should be carried through the skull on a horizontal plane about one-half inch above the root of the nose, taking care not to cut too deeply, thus avoiding injury to the brain. The upper part of the calvaria may then be pried up and off with a chisel in order to expose the interior of the skull.

Skull Section

An examination of the cut surfaces of the skull will show at a glance irregularities in thickness, which can also be brought out by looking through the skull cap against the light. The thicker portions should be noted to be made up of a compact inner and outer layer and a spongy middle layer, which is often unnecessarily given the special name diplœ. The wave-like elevations and depressions of the inner surface correspond to the grooves and convolutions of the brain. The thinner portions have no spongy layer, so that it is obvious that the mere thickness is no index of the strength, for that depends primarily upon the thickness of the compact layer. The spongy layer contains, as in other parts of the body, red bone marrow. In the adult skull irregularly distributed, roundish depressions on the inner surface of the calvaria are caused by the arachnoid granulations of Pacchioni. These depressions should be noted to lie along the main venous channels of the skull, but further details in regard to these granulations will be postponed until taken up in connection with the cerebrospinal fluid. Skulls differ very materially in their thickness, ordinarily varying in direct proportion to physical vigor.

Meningeal Vessels

The so-called meningeal arteries—in reality the nutrient arteries of the calvaria—enter the base of the skull and groove the bone deeply in their progress towards the middle line anastomosis. They are classified as anterior, **middle** and posterior **meningeal arteries,** but the large middle vessel is the only one of much practical importance. The middle meningeal divides into primary anterior and posterior branches and spreads out in progressively smaller branches over almost the whole of the interior of the skull. The corresponding veins leave the base of the skull close to the arteries, but usually through separate foramina. The middle meningeal artery grooves the bone deeply and, as will be detailed later, is very often the cause of serious complications in fracture of the skull.

The impress of the middle meningeal arteries on the removed section of the skull should be noted.

Dura Mater (Dura Mater Encephali)

The dura mater, which lines the interior of the skull, is exposed by the removal of the skull cap. The dura mater lining the interior of the skull is made up of three firmly fused layers; an outer periosteal, a middle woven fibrous or dura proper, and an inner serous lining. Due to the firm attachment of the periosteum to the inner surface of the skull, the dura mater is ordinarily partly cut during the removal of the skull-cap. The periosteal surface of the dura mater shows smaller and larger strands torn out from the bone, while the inner surface of the skull-cap is stripped of periosteum. Due to the irregularities and the foramina of the base of the skull the attachment of the dura is even firmer than over the calvaria, in fact it is almost invariably torn in line fractures of the base. The dura is very firmly attached to the numerous foramina of the base and continues, becoming semiseparated from the bony walls, into the vertebral column. This semiseparation of the dura mater spinalis from the bony wall is necessary to allow for the movements of the vertebral column, while obviously no motion is required in connection with the dura mater encephali.

Partitions

The dura mater sends semipartitions into the interior of the skull. These presumably act as stabilizers of the brain, just as, for example, semipartitions in a gasoline tank prevent the fluids from rushing too rapidly from side to side. The main semipartition runs vertically from the inner midline surface of the calvaria, extending from the roof of the nose to just beyond the external occipital protuberance. It divides the cerebrum or large brain into two hemispheres, and on account of its shape is known as the **falx cerebri** (falx = sickle; cerebrum = large brain). The falx cerebri is not a complete partition, but leaves a large space open inferiorly through which the two hemispheres of the cerebrum connect up with each other. The falx cerebri attaches to the upper surface of the **tentorium cerebelli,** which lies on about a horizontal plane and separates the cerebrum from the cerebellum (tentorium = tent; cerebellum = small brain). An open space in the front part of the tentorium, roughly an inch and a half wide by two inches long, allows for the connection of the cerebrum with the cerebellum and spinal cord. The attachments of the falx cerebri and the tentorium cerebelli to the inner surfaces of the skull raise up bony processes and ridges. The attachment of the falx just above the roof of the nose raises up the **crista galli** of the ethmoid bone (crista = comb; gallus = cock). The anterior attachment of the tentorium cerebelli runs forward into two strands, which raise up the **anterior** and **posterior clinoid processes** of the sphenoid bone (clina = bed, as in recline; a comparison with an old-fashioned four-poster bed).

Venous Sinuses

The venous and arterial supplies are, in contradistinction to the arrangement in the rest of the body, entirely unassociated within the skull. The main venous vessels or sinuses are found at the junction of the semipartitions with the lining dura mater. Thus the falx cerebri splits before joining the lining dura mater, so as to leave open a triangular space, which is known as the **superior sagittal sinus** (O.T. longitudinal). This extends from the crista galli, progressively increasing in size as it is joined by cerebral veins, back to the internal occipital protuberance. The **internal occipital pro-**

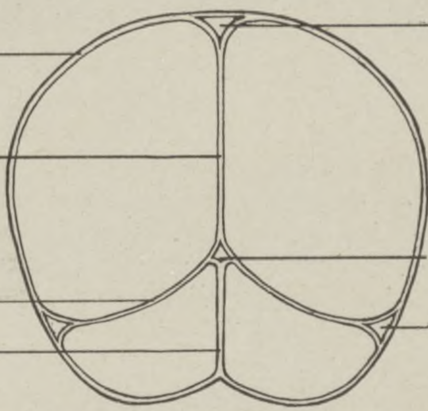


Fig. 84.—Diagram of **Dura Mater**, frontal section, posterior portion of skull.

tuberance is formed by the junction of the falx with the tentorium and lies approximately one-half inch nearer the foramen magnum than the external occipital protuberance. The position of the superior sagittal sinus on the inner surface of the skull is marked by a groove with parallel ridges. At the internal occipital protuberance the superior sagittal sinus is joined by the **rectus sinus,** which lies in the fold of junction between the falx cerebri and the tentorium cerebelli. The inferior sagittal sinus, running in the lower free border of the falx cerebri and other veins coming from the interior and base of the brain make up this straight sinus. The combined superior sagittal-straight sinuses immediately divide into two transverse sinuses, which run laterally and forward between the tentorium and lining dura. These **transverse sinuses** (O.T. lateral sinuses) progress straight to the petrous portion of the temporal bone and then make an S-shaped curve to the jugular foramen. After traversing the jugular foramina, these sinuses become the internal jugular veins of the neck. A pair of anastomosing veins ordinarily connect the superior sagittal sinus through the parietal bone with the veins of the scalp. A similar anastomosis occurs between the transverse sinuses and the mastoid scalp regions, while there are other smaller anastomosing sinuses, which will receive consideration in the later dissections.

The lining dura mater should be incised throughout its whole extent on a level with the saw-cut. Then the anterior attachment of the falx cerebri to the crista galli should be cut, and the whole lining dura turned back. The entrance of the cerebral veins into the superior sagittal sinus should be noted. By changing the position of the head the main points in regard to the semipartitions, the bony prominences, and the venous sinuses may be noted. The brain should not be disturbed until a later stage of the dissection.

Fossæ

The bones taking part in the formation of the floor of the cranium cerebrale are the frontal, the ethmoid, the sphenoid, the temporals, and the occipital. The floor of the skull is markedly irregular and is divided into **anterior, middle,** and **posterior cranial fossæ** (fossa = pit or ditch). These fossæ are progressively on a deeper plane, the floor of the anterior fossa lying roughly on a level with the supraorbital margin, of the middle fossa on a level with the zygomatic arch, and of the posterior fossa on a slightly lower level. These landmarks are only approximately true, as the floors of these fossa are in reality very irregular. The offset between the anterior and middle fossæ occurs laterally at the posterior edge of the orbital plate of the frontal bone, while medially the posterior edge of the lesser wing of the sphenoid forms its half of the boundary. The offset between the middle and posterior fossæ occurs at the ridge of the **petrous** portion of the temporal bone (petrous = stony, as in petrify). The impress of the convolutions of the brain on the bony floor is very marked over the anterior and middle cranial fossæ, while the posterior fossa is not affected by the small convolutions of the cerebellum. The impress of the grooves and convolutions on the floor of the skull is, as would be expected, much more marked than over the vault areas.

Bony Floor of Skull (Basis Cranii Interna)

The floor of the **anterior cranial fossa** is made up chiefly of the orbital part of the frontal bone, which makes the bony separation

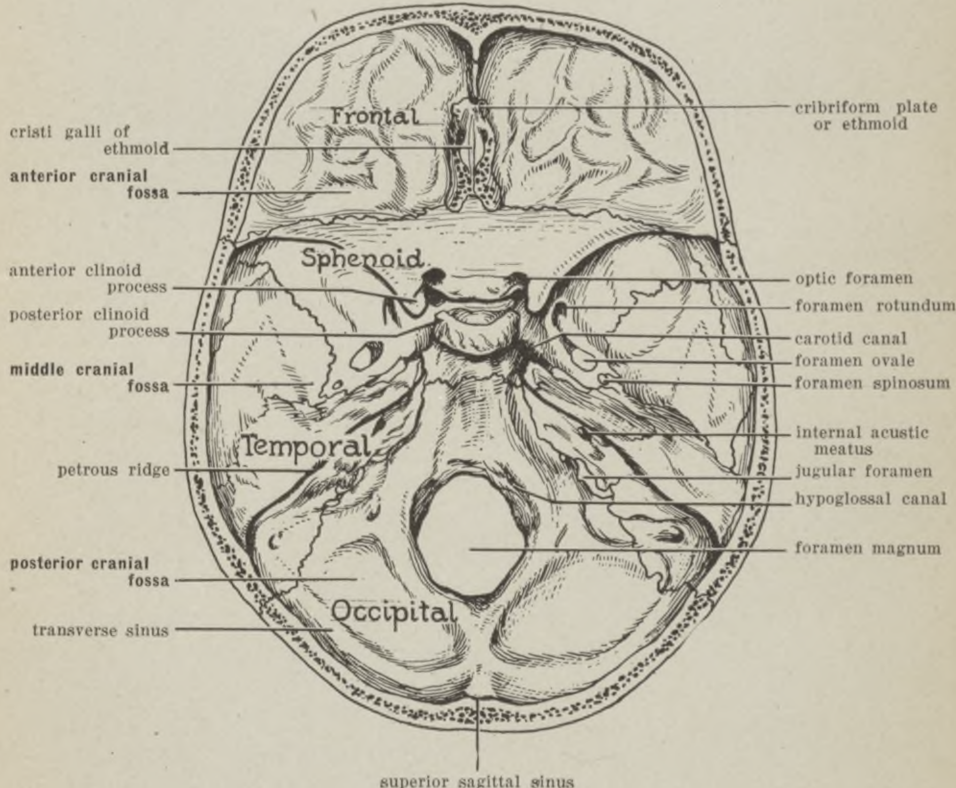


Fig. 85.—**Bony Floor of Skull** (Basis cranii interna).

between the brain and the orbital cavity. The **ethmoid bone** with its crista galli is wedged in between the two halves of the frontal bone, and sends out a small plate intervening between the brain and the top of the nose. This horizontal plate is perforated by many small holes for the passage of nerves and is therefore known as the **cribriform plate** of the ethmoid. The cribriform plate (lamina cribrosa) gives rise to the name ethmoid—that is, like a sieve. Fitting against the posterior margin of the ethmoid and joining the posterior margin of the frontal orbital plate lie the lesser wings of the **sphenoid bone.** The sphenoid bone is compared in nomenclature to a butterfly, having a body and lesser and greater wings (alæ parvæ et magnæ).

The anterior and medial portion of the floor of the **middle cranial fossa** is made by the **body** and **greater wings of the sphenoid bone.** Between the greater and lesser wings of the sphenoid lies a narrow slit known as the **superior orbital fissure** (O.T. sphenoidal). This triangular fissure can be seen when looking into the back of the orbital cavity and exists as a passageway between the cranial cavity and the orbita. The anterior clinoid processes are projections from the lesser wings, while the posterior clinoid processes belong to the body of the sphenoid bone. The deep space between the clinoid process is usually called the **sella turcica,** or turkish saddle. This changes the comparison previously used to derive the term clinoid, for to maintain the same figure of speech the term clina should be used. In the posterior cranial fossa the sphenoid forms a solid bony junction with the occipital bone, the cartilage ordinarily disappearing entirely in the adult. The posterior and lateral portion of the middle cranial fossa is formed by a plate of the temporal bone.

The floor of the **posterior cranial fossa** is made up essentially by the part of the occipital bone, which intervenes between the cerebellum and the muscles of the neck. This is very much the thickest and strongest portion of the base of the skull, serving as a protection for the most vital region of the body, as will be noted in connection with the detailed consideration of the brain. In the anterior portion of the occipital bone lies the **foramen magnum,** the opening between the skull and the vertebral column. A strong portion of the temporal bone joins at a suture line the front edge of the occipital bone. In this suture line, just lateral to the anterior portion of the foramen magnum, lies the jugular foramen.

Many of the suture lines in the base of the skull become very faint in later life, and some, as, for example, the sphenooccipital, in reality disappear entirely.

Cranial Nerves (Nervi Cerebrales)

In order to gain a clear conception of the openings in the floor of the skull, it is necessary to consider summarily the arteries, veins, and nerves, which enter or leave the skull.

The twelve pairs of cranial nerves are classified as follows:

	NERVE.	FUNCTION.	EXIT FROM SKULL.
I.	or olfactory	smell	cribriform plate of ethmoid
II.	or optic	sight	foramen in lesser wing of sphenoid
III.	or oculo-motor	motor to eye	superior orbital fissure
IV.	or trochlear	motor to eye	superior orbital fissure
VI.	or abducent	motor to eye	superior orbital fissure
V.	or trigeminal	sensory of head	ophthalmic division — superior orbital fissure maxillary division—foramen rotundum mandibular division — foramen ovale
VII.	or facial	motor of head	internal acustic meatus
VIII.	or acustic	hearing	internal acustic meatus
IX.	or glossopharyngeal	taste, etc.	jugular foramen
X.	or vagus	heart, etc.	jugular foramen
XI.	or accessory	joins vagus, etc.	jugular foramen
XII.	or hypoglossal	motor to tongue	hypoglossal canal

Cranial Arteries

The internal carotid arteries enter the interior of the skull along the sides of the sella turcica of the sphenoid bone. The internal carotid artery enters the base of the skull just in front of the jugular vein, but whereas the **carotid canal** curves forward sharply the jugular vein turns backward. The vertebral arteries go through the foramen magnum, and eventually will be noted to anastomose about the base of the brain with the internal carotids. The middle meningeal artery, a branch of the internal maxillary, enters at the posterior tip of the greater wing of the sphenoid, through the **foramen spinosum.** A minor anastomosis will later be noted between the intra- and extracranial arterial systems.

Veins

The main venous trunks leaving the skull are the internal jugulars. A number of anastomoses between the intra- and extracranial venous systems take place as will be noted in the later regional dissections. These anastomoses are very important clinically on account of the danger of infective clot blockade spreading from diseases of the face and scalp.

Dissection.—In order to obtain a view of the floor of the skull, the brain must be removed. With the head tilted back so that gravity tends to pull the brain posteriorly, if not previously done, the dura should be incised all the way around at the same level as the saw-cut. Then the falx cerebri should be cut across from its attachment to the crista galli. The cerebrum will tend to fall out, but is connected with the cerebellum, which is still firmly held in its posterior cranial compartment. The tentorium cerebelli should then be cut close to its attachments to the bony walls. The various nerves and vessels, which connect with the base of the brain, should next be cut across at a convenient midpoint. The entire brain should then be removed from the skull, and should be kept moist and carefully preserved for future study. The floor of the skull is exposed by this dissection for detail examination.

Foramina

The only pair of cranial nerves in the anterior fossa are the olfactory. A bulbous tract of the brain lies directly over the cribriform plate of the ethmoid and sends numerous fine branches into the nasal cavities.

The second, third and fourth pairs may be noted to pierce the dura in the middle cranial fossa. The fifth and sixth pairs pierce the dura under the tentorium cerebelli, but run forward on each side of the body of the sphenoid under the dura mater into the middle cranial fossa. The large optic nerves should be noted to pass through a separate foramen in the lesser wing of the sphenoid bone, situated just medially to the anterior clinoid process. All the oculomotor nerves and the trigeminal lie under the dura mater for some distance and consequently can not be followed to their foramina until the dura is dissected off. The middle meningeal artery enters through the base of the skull at the foramen spinosum in the posterior tip of the greater wing of the sphenoid. The spine which gives this foramen its name is raised up on the neck surface of the base by a ligament attachment.

The seventh to the twelfth cranial nerves, inclusive, arise under the tentorium and make their exit from the posterior cranial fossa. The facial and the acustic both enter the internal acustic meatus on the posterior surface of the petrous portion of the temporal bone. The glossopharyngeal, vagus, and accessory nerves should be traced to the jugular foramen, while the hypoglossal runs lower down through its separate canal of the occipital bone.

Middle Cranial Fossa

The dura mater should be carefully dissected off one side of the sphenoid bone, while the other side remains undisturbed for comparison. The oculomotor nerves, the third, fourth, and sixth, should be traced forward under the dura to the superior orbital fissure. The trigeminal or fifth nerve enters this space as a single trunk, which immediately spreads out to form the **semilunar** or Gasserian **ganglion**. From this ganglion three trunks are given off; the ophthalmic division running straight forward to the superior orbital fissure, the maxillary division running forward to the foramen rotundum, and the mandibular division running directly downward into the foramen ovale. The foramen rotundum is located near the junction of the greater wing with the body of the sphenoid bone, while the foramen ovale is in the posterior part of the greater wing. A branch from the facial nerve centers of the brain stem, traveling as a separate strand, follows the mandibular division through the foramen ovale. This entire nerve, that is, the root, ganglion, and divisions, lies protected within a white fibrous connective-tissue sheath in its course under the dura mater to its foramina of exit from the skull.

Cavernous Sinus

A large cavernous venous sinus drains the ophthalmic or eye vein and empties posteriorly into the transverse sinuses. This cavernous sinus lies along the sides of the body of the sphenoid and sends anastomosing branches through the base of the skull. One branch leading back along the ridge of the petrous portion of the temporal bone to the transverse sinus is known as the **superior petrosal sinus.**

The other branch runs from the posterior extremity of the cavernous sinus practically straight backward to the jugular foramen, and is known as the **inferior petrosal sinus.** The two cavernous sinuses are connected by transverse anastomosing branches. Nerves are embedded in the walls of the cavernous sinus, while the internal carotid artery literally traverses the sinus in its course to the interior of the skull.

Hypophysis

The hypophysis is a globular gland, which is roughly about a quarter of an inch in all diameters, and is held firmly encased by dura on the sella turcica (O.T. pituitary gland). It is made up of an anterior lobe developed from the pharyngeal mucosa and a posterior lobe developed from the brain. The anterior lobe is separated by the body of the sphenoid bone from the nasopharynx, while the posterior lobe retains via a stalk or infundibulum its connection with the brain. This infundibulum was necessarily cut or torn across in the removal of the brain.

The gland is commonly considered to be of the ductless type, and is essential to a regulated growth of the body, if not to life itself. Its proximity to the optic nerves explains anatomically the liability to vision disturbances in overgrowth of this gland. The function of the pharyngeal and of the brain lobes is different, consequently under- and overactivity of the anterior and of the posterior lobe are theoretically at least recognizable in the clinic.

Fractures of the Skull

The rounded surfaces of the calvaria, utilizing the arch construction, tend to make ordinary blows glance off the skull without serious injury. Severe, sudden impacts centered over a small area tend to produce localized depressed fractures, ordinarily without linear spreading. The temple region, owing to the anatomic fact that it is thin and not arched, offers the least resistance to this form of injury. Severe blows striking the skull squarely and spread out over a large area tend to produce line fractures. These linear fractures tend to run through the base of the skull on account of its thinness, its foramina and its relative flatness. Any blow sufficiently severe to cause a fracture will necessarily cause more or less injury to the brain itself, characterized clinically by the symptoms of concussion. Fractures can be located by incising the scalp or can often be visualized by the use of the x-ray.

Clinical Signs of Fracture

If the fracture runs through the cribriform plate of the ethmoid or the petrous portion of the temporal bone, the dura is practically always torn open, allowing cerebrospinal fluid to escape into the nose or ear. This escape of cerebrospinal fluid fixes the diagnosis, and on account of the great danger of meningitis is a most serious complication. If the fracture runs through the orbital part of the frontal bone a hemorrhagic collection in back of the eye is the characteristic symptom. If the dura is torn in any fracture of the skull, unclotted blood may be found by lumbar puncture diffused throughout the cerebrospinal fluid, although obviously this might, on the other hand, come from the lacerated brain substance itself. Most linear fractures do not tear the dura mater of the calvaria, but simply loosen its attachments to the skull. If, then, one of the nutrient bone arteries is cut by the jagged edges of the skull, an extradural hemorrhage collects. The symptomatology of a middle meningeal extradural hemorrhage is a more or less marked paralysis of the opposite half of the body, the reason for which will be noted in connection with the detailed study of the brain. A tear through the venous sinuses of the skull will show practically no clinical symptom on account of the low pressure in the veins.

It is obvious that in a case of fracture of the base of the skull some of the cranial nerves may be destroyed, either at their foramina or along their course from the brain stem to the foramina. The sixth or abducent nerve is particularly exposed to injury on account of its long course between the dura and skull. The localization will be dependent upon the particular nerves destroyed, which can only be determined by a consideration of their course, function, and distribution. The connection of the cranial nerves with the brain will later on be taken up in detail.

CENTRAL NERVOUS SYSTEM

All the nerves of the body are connected up with and regulated through the central nervous system, which is made up of the spinal cord (medulla spinalis) and the brain (encephalon). The spinal cord in all the vertebrates is protected in the bony vertebral column and the brain by the cranium cerebrale. The word brain is often applied to the cerebrum alone and at other times to the whole nervous contents of the skull. To avoid this possible source of confusion, the technical term **encephalon** is justly gaining in usage and will be used throughout this description. An uninjured central nervous system is obviously essential for the proper functions of the body, and certain parts of it even for life itself.

Development

The beginning of nervous tissue in the vertebrate embryo is in the formation of a **dorsal ectodermal groove.** This groove lies in the midline, directly back of the cartilaginous notochord, and

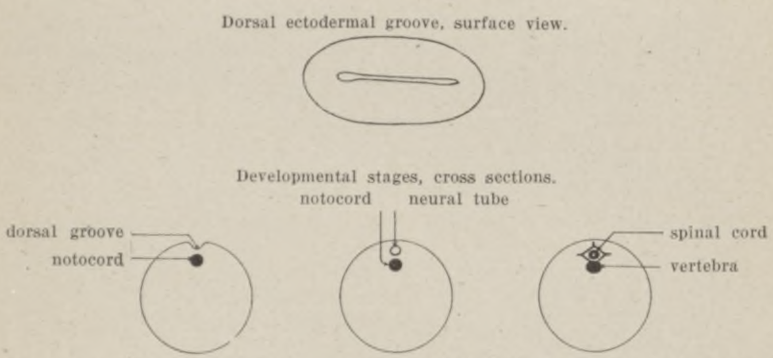


Fig. 86.—Development of **Spinal Cord** (medulla spinalis).

extends throughout the length of the embryo. The notochord is a continuous cartilaginous rod, which serves as the basis for the development of the bodies of the vertebræ. The dorsal ectodermal groove deepens and finally becomes constricted off from the surface, forming the **primitive neural tube,** as illustrated in the diagram. The walls of the primitive neural tube are made up of developing nerve cells, which are technically known as neuroblasts. These neuroblasts are at first noncharacteristic roundish cells without processes, which later develop processes and then become known as neurons—that is, nerve cells. The developing verterbræ send back their arches, which protect the neural tube laterally and posteriorly, while at the head end the cranium cerebrale develops. That some of the connective tissue elements of the central nervous system are developed from ingrowths from the mesoderm seems *a priori* plausible, but this proposition has been negated by convincing scientific proof. The meninges, the dura, arachnoidea and pia are developed from the mesoderm, as are the connective-tissue sheath coverings of the peripheral nerves.

The lamina and spinous processes occasionally fail to grow together in back of the spinal cord, so that only the skin, fascia, and meninges protect the nervous system. This malformation occurs more frequently in the lumbar region and, if it is at all large, the dura and skin are commonly bulged out by the pressure of the cerebrospinal fluid.

Nerve Cell (Neuron)

The bodies and processes of nerve cells are gray in color. The ordinary peripheral nerves and a great part of the central nervous system appear an ivory white, but this is due to the addition of the medullary or myelin insulating sheaths around the small gray axis cylinder processes. The special connective tissue cells of the nervous system are known as the **neuroglia** (glia = spider-like). Some nerve cells are about the size of a red blood capsule, but the great majority are distinctly large cells, a dozen or more times greater in diameter. The axis-cylinder processes are in many cases three feet or more long, extending, for example, from the spinal cord to the sole of the foot. The dendritic processes terminate in relatively short branches, which make connections with similar processes of neighboring cells. The neuroblasts, after a certain stage of fetal development, change into nerve cells, which do not possess the power of reproducing themselves. No new nerve cells are produced after birth, but if processes are cut across, it is possible for the body of the nerve cell to send out new processes. The growth of the encephalon after birth is probably in part to be attributed to increase in the size of the individual cells and sheaths, although there may well be other factors.

Ganglia

Aggregations of the bodies of nerve cells held together by connective tissue are known as ganglia and are gray in color. As the nerve processes of the sympathetic system grow out from the central nervous system towards the surface, neuroblasts commonly follow along the progressing axis-cylinder processes. The primary set of ganglia developed are those of the sympathetic gangliated trunks, which lie along the sides of the bodies of the vertebra. The secondary set are the prevertebral ganglia, named according to their position and function, the cardiac, the epigastric, the hypogastric, and so forth. A tertiary set of ganglia may be found, microscopically, scattered in the various organs of the body—for example, in the heart, lungs, and gastrointestinal tract—being known as the visceral ganglia. These ganglia belong to the sympathetic nervous system and are not found in connection with voluntary segmental nerves outside of the skull and vertebral column. Most of the sympathetic nerves have a medullary sheath, while a few are nonmedullated and consequently appear gray in a fresh body. The sympathetic is often referred to as the vegetative nervous system, as it is not under the control of the will.

Efferent versus Afferent Neurons

Nerve cell processes differ from an ordinary insulated wiring system, inasmuch as nerve messages can only be sent in one direction on any given nerve process. The nerve processes, which possess the power of carrying messages away from the central nervous system are known as the efferent, while those leading to the central nervous system are known as afferent (ferro = carry; e = away; ad = towards). The motor nerves obviously belong to the efferent class, while the sensory belong to the afferent class. Most of the peripheral nerves are made up of an admixture of both types of processes, though in special cases, for example, in the head, many of the nerves are made up exclusively of one class. That most of the sympathetic nerves also are made up of mingled efferent and afferent fibers seems probable, although the presence of afferent fibers is for obvious reasons not so readily susceptible of absolute proof.

These last three topics are discussed with greater detail in the introductory chapter on nerves, pp. 61 to 64.

Spinal Cord (Medulla Spinalis)

Both the voluntary and the sympathetic nerves connect up segmentally through the intervertebral foramina with the spinal cord. The dura mater wraps around these segmental nerves as a funnelshaped protector and continues peripherally, eventually blending with their connective-tissue coats. Each segmental nerve bundle travels a varying distance inside the dura until within about one-half inch of the spinal cord, when it divides into an **anterior** and a **posterior root.** The anterior root, which runs to the anterolateral portion of the spinal cord, is made up exclusively of efferent processes, while the posterior root, which runs to the posterolateral portion of the cord, contains only afferent processes. The characteristic feature of the posterior root is the presence of a ganglion, which is enclosed in the dura and located just peripherally to the intervertebral foramen.

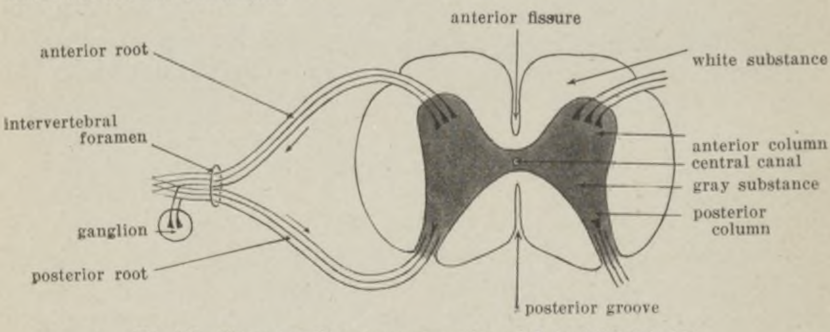


Fig. 87.—Diagrammatic transverse section of **Spinal Cord** (x 10).

Cross-Sections of Spinal Cord

The spinal cord varies in different segments, but is roughly one-quarter times three-eighth inches in diameters. An H-shaped gray substance (substantia grisea) can be readily distinguished in a fresh specimen by the unaided eye from the surrounding white portions (substantia alba). The white portion is made up in the main of processes connecting the encephalon with the various segments of the spinal cord, of both the efferent and afferent classes, but also contains shorter processes, which interconnect between various levels of the cord. Logically the white area must then be largest at the upper part of the neck, and progressively smaller down to the termination of the spinal cord opposite the first lumbar vertebra. For all the processes connecting the spinal cord with the encephalon must pass through the neck region, whereas in the lumbar region only the white processes interconnecting between the lower part of the body and the encephalon are to be found. The gray portion is made up essentially by the nerve cell bodies of the segmental nerves, but possesses also some neuroglia cells. Logically, therefore, the gray substance must be largest where the segmental nerves are the largest, that is, where the brachial and lumbosacral plexuses join the cord (intumescentia cervicalis et lumbalis). The greater size of the anterior column of the H-shaped gray substance is due to the fact that all the cell bodies are found in this area, instead of partly in the root ganglia, as is the case with the posterior root.

The anterior or efferent roots are composed chiefly of the motor processes, both of the voluntary and involuntary musculature. Very probably many other kinds of activity of not so obvious a nature are also dependent upon impulses through this anterior root. The posterior or afferent roots are composed chiefly of sensory processes, which connect mainly with the cutaneous surfaces, but also with various other parts of the body. It is known, for example, that the fascias and muscles have a rather limited sensory supply, but that the bones, joints and endothelial surfaces have very acute sensation. On account of the plexus arrangement of the spinal nerves, no one segmental nerve ever completely supplies a segment of the body, there being always considerable overlapping in the peripheral distribution.

Peripheral Neurons

The nerves having their cell bodies in the anterior column of the spinal cord or in the posterior root ganglia are known as the peripheral neurons (peri = around; phero = carry). Even though their bodies lie in or near the spinal cord, these nerves belong to the peripheral system of neurons on account of their distribution. The nerve processes connecting up these cell bodies of the various levels of the spinal cord with the encephalon, making up the white substance of the spinal cord, belong to the central system of neurons.

A reflex muscular action may be brought about in a normal individual by tapping the tendon of a stretched muscle, provided the patient's attention is distracted from the procedure. The contraction of a muscle thus brought out is known as a **spinal cord reflex.** It should be specially noted that the condition of the encephalon and upper portions of the spinal cord have nothing to do with this action. The message travels up from the muscle through the posterior root into the particular segment of the spinal cord, crosses over to the motor cells of the anterior column, and travels down the anterior root to the muscle. This reflex takes place even though the spinal cord be completely severed above this point. The fact is, in time it becomes exaggerated under these abnormal circumstances. But if either the anterior or posterior root neurons are destroyed by accident or disease, the circuit is interrupted and no spinal cord reflex is possible.

Locomotor ataxia, a late syphilitic nervous degeneration, is typical of the diseases characterized by a destruction of the posterior roots. When this disease is advanced, the patient has a very marked diminution of all sensibility and no spinal cord reflex. Clinically the painless, badly injured joints, the lack of muscular balance with the eyes shut, and the absent reflexes are readily explicable on the anatomic basis.

Infantile paralysis is produced by a poison, which selectively destroys the motor cell bodies of the anterior column. The resulting paralysis and the absence of spinal cord reflexes characteristic for this disease is also readily explained by the anatomic considerations. Results similar to these are obtainable experimentally by the sectioning of the anterior or posterior roots. The presence of a normal spinal cord reflex then means that the afferent and efferent peripheral neurons are intact, nothing more and nothing less.

Central Neurons

But these peripheral neurons must be connected up with the cerebrum, if consciousness of pain or voluntary motion is to be obtained. The nerve processes connecting up the peripheral neurons with the cerebrum belong to the **afferent** and **efferent** central neurons. These central processes may connect directly from the cerebral cortex to the cell bodies of the anterior or posterior column of the various levels of the spinal cord. These processes usually, however, stop one or more times en route in some mass of gray substance, while a new process travels the remainder of the distance. If the motor cells of the cortex of the cerebrum, or their processes in any part of their course to the anterior column cell bodies are destroyed, no voluntary motion of the part is possible. But the spinal cord reflex is not interfered with and after a variable period of time even tends to become exaggerated. Similarly if the sensory cells of the cerebral cortex, or their processes in any part of their course from the cortex of the cerebrum to the cell bodies of the posterior root are destroyed, no consciousness of pain is possible. But again the spinal cord reflex is not interfered with.

If an individual can not move a part of the body, the condition is called paralysis. This may be due to the disease of the peripheral motor neurons or of the central motor neurons. The presence of a spinal cord reflex would tend to demonstrate that the peripheral motor neurons are intact and that therefore by exclusion the disturbance must be in the central motor series. The same logic obviously applies to the question of absence of sensation.

Tracts of Spinal Cord (Fasciculi Medullæ Spinalis)

The nerve processes connecting up the cell bodies of the various levels of the spinal cord with the encephalon run in group bundles through the white substance of the cord. In the normal adult spinal cord it is absolutely impossible to find any trace of these bundles. These group bundles make up the fasciculi or tracts of the spinal cord, and have been demonstrated primarily by a study of their disappearance in disease. Due to the fact that in fetal life certain of these tracts develop their medullary sheaths earlier than others, our knowledge derived from a study of diseased spinal cords has been corroborated and added to.

The **anterior** and **lateral cerebrospinal tracts** are logically so named on account of their function and their position in the white substance of the spinal cord. They were formerly known as the direct and crossed pyramidal tracts, respectively, because they form pyramid-like structures on the anterior surface of the medulla oblongata, the connecting portion between the spinal cord and the upper portions of the nervous encephalon. These tracts are made up of the processes of the central motor neurons, which connect up the cortex of the brain with the cell bodies of the anterior column of the spinal cord. The lateral cerebrospinal tract crosses over from one side to the other in the medulla oblongata, while the anterior cerebrospinal tract also eventually crosses, but only when its processes have reached their terminating level in the spinal cord. The **cerebellospinal tract** lying in the superficial lateral portion of the white substance, will later be traced into the cerebellum, at which time its function will be considered. The two main sensory tracts are to be found side by side in the posterior segment of the white substance of the spinal cord. The medially situated of these tracts is known as the **gracilis tract** of Goll, while the lateral is known as

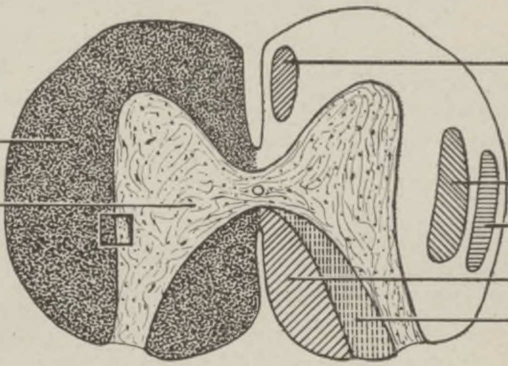


Fig. 88.—Diagram of Tracts (fasciculi) of Spinal Cord (x 10).

the **cuneatus tract** of Burdach, or if these names are forgotten they might be identified simply as the posterior median and posterior lateral tracts. Other tracts, anatomically less defined and functionally less important, make up the remainder of the white substance of the spinal cord. Many of these other tracts are processes interconnecting various levels of the spinal cord.

Fig. 89.—Showing junction of white and gray substances (x 100).

Dissection.—The coverings and gross appearance of the spinal cord were considered with the dissection of the vertebral column, page 235. If any of the remaining material contains parts of the spinal cord it should prove of great advantage to repeat this dissection. Unfortunately in the dissecting room bodies the spinal cord is so altered in color and consistency that gross cross-sections are ordinarily practically valueless. In order to obtain a just conception of the gross color markings and consistency of the spinal cord, it is absolutely essential to obtain a part of a fresh cord from one of our domestic animals. The surprising feature of a fresh normal spinal cord to the elementary student is its very marked delicacy as contrasted with the peripheral nerves previously considered. This difference in strength and consistency is presumably related to their relative exposure to injury, the central nervous system being well protected, while the peripheral nerves are relatively exposed. The strength of the peripheral nerves is due essentially to their thick, white fibrous connective-tissue sheaths, which, however, do not continue inside of the dura mater. While the pia mater and the blood vessels do carry some ordinary white connective tissue into the central nervous system, most of the connective-tissue function is assumed by the relatively delicate and sparse neuroglia cells. The parts of the peripheral nerves which connect with the spinal cord and encephalon are so delicate that it does not require much strain to tear them or pull them out from their origins.

The discussion in regard to the tracts and gray substance of the spinal cord at various levels can be followed by studying the diagrams in the larger atlases, or preferably the actual microscopic sections. It is obvious that much of the foregoing discussion can not be actually demonstrated, as it is based on a compilation of knowledge derived from various sources.

Development of Encephalon

The encephalon makes its first appearance as an enlargement of the cephalic end of the neural tube. In the lower animals the head end is obviously the first part of the body to come into relation with any new object, and consequently is best fitted to gather special information, which may then be transmitted to the rest of the body. The primary tubular structure of the cephalic portion of the neural tube divides after a short period of development into three vesicles (vesicle = bladder). These vesicles are known from in back forwards as the rhombencephalon, or hindbrain (has rhomboid-shaped interior cavity), the mesencephalon, or midbrain, and the prosencephalon, or forebrain. As development progresses the rhombencephalon divides into three vesicles, which are known embryological-

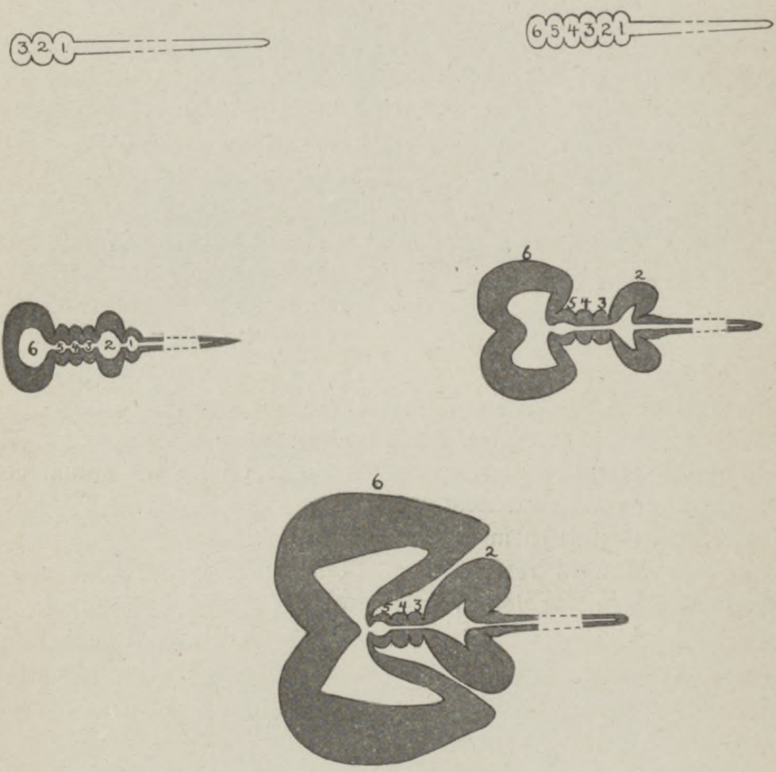


Fig. 90.—Developmental stages of **Encephalon.**

Division 1—medulla oblongata	myelencephalon		
" 2—cerebellum	metencephalon	rhombencephalon	
" 3—isthmus rhombencephali	isthmus rhombencephali		
" 4—mesencephalon	mesencephalon		
" 5—diencephalon	diencephalon	cerebrum	
" 6—cerebral hemispheres	telencephalon		

ly as the myelencephalon, the metencephalon, and the isthmus rhombencephali, forming in the fully developed status the medulla oblongata, the cerebellum with its portion of the brain stem, and the isthmus rhombencephali, respectively. The mesencephalon does not undergo any marked changes, its interior cavity remaining small and in the fully developed status persisting as a narrow duct. The prosencephalon divides into two vesicles, which are known as the diencephalon and the telencephalon (di = separate as in divide; tel = end or distant as in telephone). Further development of these six primary vesicles gives rise to the subdivision of the encephalon which will be referred to in this text as the **medulla oblongata,** the **cerebellum,** the **isthmus rhombencephali,** the **mesencephalon,** the **diencephalon** and the **cerebral hemispheres.** The lateral development in the higher animals is characterized by the great increase in the cerebral and cerebellar divisions, while the other parts increase relatively little. The cerebral hemispheres keep on increasing in size until by birth they are roughly a dozen times as large as the combined medulla oblongata, cerebellar, mesencephalon and diencephalon subdivisions of the encephalon.

Vesicles, or Ventricles

The walls of these developing vesicles are made up essentially of neuroblasts, the cells which undergo division to form the permanent nerve cells of the encephalon. The cavities inside these vesicles communicate freely and join the neural tube cavity of the spinal cord region. During these developmental changes blood vessels from the outside grow into these cavities and commence the secretion of cerebrospinal fluid. In the literal sense of the words these vessels do not enter the vesicles, but carry in before them a fold of epithelium, which forms a covering over the network of arteries, capillaries and veins. The relationship here is the same as the intestines have to the peritoneal cavity and the lungs to the pleural cavities. This layer of epithelial cells, technically known as the lamina chorioidea epithelialis, controls the secretion of the cerebrospinal fluid (chorioid = rich network of small vessels). The name of the interior cavities during later development is changed from vesicles to ventricles, the term ventricle referring to their alleged stomach-shape. At first there is no connection between the vesicotubular interior of the central nervous system and the pia-arachnoid space, but later foramina develop secondarily. The cerebrospinal fluid then under normal conditions escapes out of the ventricles via foramina into the pia-arachnoid endothelial sac, as will be detailed later.

Encephalon

The encephalon after birth is made up of gray and white substance, with the same significance as in other parts of the nervous system. The gray substance of the encephalon is not distributed regularly as in the H-shaped center of the spinal cord, although in the medulla oblongata, and in the mes- and diencephalons this condition is approximated. The white processes connecting the cerebrum with the spinal cord must obviously traverse the medulla oblongata, the base of the cerebellum and the mes- and diencephalons in order to reach their destination, while the cell bodies of the cranial nerves tend to lie inside of these white tracts. But in the case of the cerebrum and cerebellum the gray substance is characteristically distributed over the outer surface or cortex throughout its whole extent, although they both do possess some large internal masses of gray substance. This gray cortical area is increased markedly by the presence of grooves (sulci), which mark off the convolutions (gyri). The convolutions average about one-quarter of an inch in width in the human cerebrum, but are only about one-tenth as wide in the cerebellum.

Tracts of Brain Stem

Our knowledge of the various tracts of the nervous encephalon is dependent upon the same basis as in the case of the white substance of the spinal cord, that is, the study of the white substance in disease and in the stages of development. All the efferent and afferent tracts connecting up the spinal cord with the cerebral hemispheres run through the medulla oblongata, base of the cerebellum, and the mes- and diencephalons. The connecting tracts between the cerebral hemispheres and the spinal cord, plus a considerable amount of incidental gray substance, is commonly called, as a matter of convenience, the brain stem. The central motor nerve cell bodies lie about the mid-lateral surface of the cortex of the cerebrum and send their axis-cylinder processes down through the brain stem to the anterior column cell bodies of the various levels of the spinal cord. These nerve processes may theoretically traverse the whole distance themselves, or, as probably happens more commonly, may relay through masses of gray substance and other neurons to their distribution. These masses of gray substance within the brain stem and cerebral hemispheres are known as **nuclei**, the term ganglion being reserved for the knot-like masses of gray substance to be found along the course of the peripheral nerves.

The majority of the motor nerve processes make up the **pyramids** of the medulla oblongata, which can be noted macroscopically on its anterior surface, one on each side of the median line. The greater

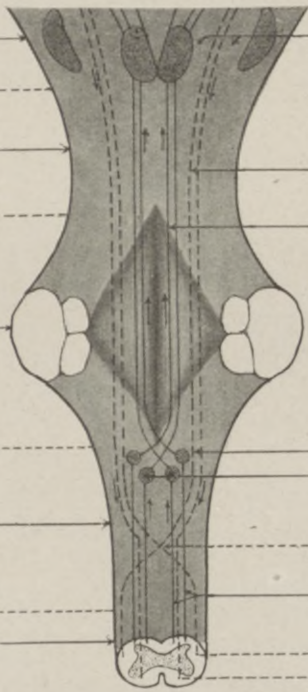


Fig. 91.—Diagram of **Tracts** (fasciculi) **of Brain Stem.** (Posterior-superior view with tracts projected to surface and cerebellar hemispheres removed.)

number of these processes cross in the medulla oblongata and make up the lateral cerebrospinal tracts of the medulla spinalis, while the remainder, which continue straight down, make up the anterior cerebrospinal tracts. The main sensory tracts of the spinal cord, the fasciculus gracilis (posteromedian) and the fasciculus cuneatus (posterolateral) terminate in nuclei of the same names in the posterior portion of the medulla oblongata. These tracts, however, do not really stop in these masses of gray substance, but processes arising from these nuclei carry the sensory tracts upward through the brain stem to terminate eventually in the cortex of the cerebrum just posterior to the motor area. These processes form the **medial lemnisci,** which course anteriorly within the medulla oblongata and about its middle cross over to the opposite sides. The cerebellar tract of the spinal cord carries afferent processes into the cerebellum and hence traverses only the oblongata portion of the brain stem. The other tracts, which have been located anatomically in the white substance of the brain stem, are of lesser functional importance, and, therefore, of lesser interest for our purposes.

Gray Substance of Brain Stem

In the brain stem as in the spinal cord lies gray substance, but as previously noted, it is irregularly scattered. This gray substance is made up in the main of the **peripheral efferent and afferent nerve cells** of the cranial nerves. The fifth, or trigeminal, nerve has its peripheral nerve cell bodies in the semilunar ganglion, which corresponds to the ganglia on the posterior roots of the spinal cord nerves. This same arrangement and logic holds good in connection with the glossopharyngeal and sensory portion of the vagus, these cell bodies forming the ganglia on the nerve trunks near the jugular foramen. The peripheral neurons of the olfactory, optic and acoustic nerves differ from the previously considered arrangement in being made up of a series of neurons with intervening processes and ganglia, instead of a single axis-cylinder process extending all the way to the brain stem. The peripheral neurons of the cranial motor nerves have their cell bodies, as would be anticipated, inside of the brain stem. The central neurons connect up this gray substance of the brain stem with the cerebral hemispheres, just as occurred in connection with the spinal cord. In the case of the head, then, it is possible to get a **brain stem reflex,** which is really the same thing as a spinal cord reflex, provided the peripheral afferent and efferent neurons are intact. This holds true no matter what the condition of the central afferent and efferent neurons be, that is, whether the individual can feel or move, or not. The gray substance of the medulla oblongata is peculiarly important on account of the presence of the centers for the heart and respiration.

Lateral View of Encephalon

The encephalon is made up of a dome and a base portion, corresponding to the skull structure. The falx cerebri has been noted to divide the cerebrum by a deep midline depression into two cerebral hemispheres. The irregularities of the floor of the skull necessarily affect the contour of the basal portion of the brain. The cerebral area fitting into the anterior cranial fossa is known as the **frontal**

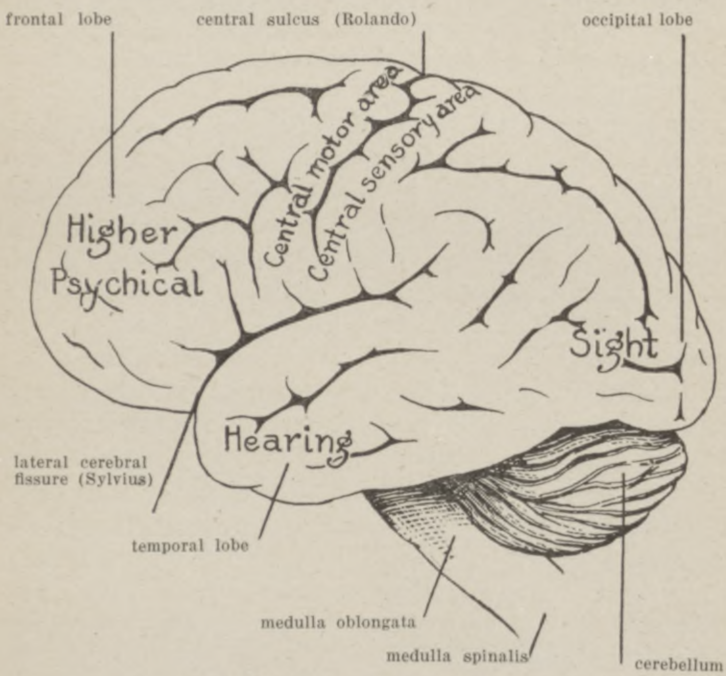


Fig. 92.—Lateral surface of **Encephalon.**

lobe; in the middle cranial fossa, as the **temporal lobe**; and over the tentorium cerebelli, as the **occipital lobe.**

The offset between the frontal and temporal lobes of the cerebrum is continued as a deep depression between these areas over the lateral surface of the cerebrum, gradually becoming shallower as it extends backward and upward. This marked and deep depression is known as the **lateral cerebral fissure** of Sylvius, which it might be well to note here serves as the route for the lateral cerebral artery. By separating the lips of the lateral cerebral fissure a depressed area of the cerebral cortex may be noted, which is known as the insula, or, popularly, island of Reil.

The grooves (sulci) and convolutions (gyri) of the surface of the brain are always individualistic, just as the surface markings of the thumb, for example. But they are invariably on a fixed plan so that the lateral cerebral fissure of Sylvius and the important central sulcus can always be made out. The **central sulcus** of Rolando turns around the medial falx cerebri surface of the cerebrum slightly in back of the midpoint anteroposteriorly. It runs laterally, downward and forward, generally with two angles in its course, and ends near the lateral cerebral fissure. The central sulcus is a very important localization, for just in front of it lie the cell bodies of the central motor neurons, while just in back lie the central sensory neurons. The head is controlled by these cells nearest the lateral cerebral fissure, while the neck, thorax, abdomen, and lower extremities follow in regular sequence towards the median line, so that the feet, for example, are controlled by those cells lying nearest the middle line. The frontal lobes of the cerebrum are the higher intellectual centers, which fact gives an anatomic foundation for the popular association of the high doming forehead with intelligence. The temporal lobes of the cerebrum is the area for central hearing, which is connected up with the peripheral acoustic centers in the brain stem. The occipital lobe of the cerebrum is the area for central vision, and is connected up with the peripheral optic centers in the mes- and diencephalons. The brain anatomically shows no signs of these localizations, which have been made out chiefly by a study of the symptoms of brain diseases compared with the anatomical changes.

The lateral surfaces of the cerebral hemispheres should be examined.

Cerebellum

The cerebellum functionates as that part of the encephalon which controls balance. One tract from the spinal cord into the cerebellum and another tract between the cerebrum and the cerebellum have been made out by the usual methods. By manipulating the hemispheres of the cerebellum these tracts may be noted macroscopically as they leave the brain stem to enter the base of the cerebellum. The spinal cord-cerebellar tract raises an elevation on the posterior surface of the medulla oblongata, which is known as the corpus restiform, while the cerebrocerebellar tract raises up a visible bundle on the posterior surface of the mesencephalon, which is known as the brachium conjunctivum. The white interior area of the cerebellum is compared for descriptive purposes to the branches of the tree of life, technically arbor vitæ. Every section through the cerebellum shows this tree-like white structure coated by a thin gray cortex.

The characteristic symptom of cerebellar disease is a disturbance in balance. This symptom, however, may be due to a failure of messages to reach the cerebellum and not to disease of the organ itself. For example, if the spinal cord-cerebellar or the cerebrocerebellar tracts were destroyed in any part of their course, the loss of balance sense would be marked even though the cerebellum itself were intact. Sight, as a matter of common knowledge, is an important factor in maintaining balance, more especially so if other afferent messages are cut off from the cerebellum, as for example in locomotor ataxia. The semicircular canal nerves, a special organ of equilibrium in the petrous portion of the temporal bone, connect up with the cerebellum. The detailed consideration of this organ will be postponed until reached in connection with the study of the internal ear. While a diminution in the sense of balance is an invariable accompaniment of serious cerebellar disease, this symptom should only be attributed to cerebellar disease when the other common sources of the trouble can be excluded.

The cerebellar hemispheres and their connection with the brain stem should be examined.

Base of Encephalon

The main irregularities of the base of the encephalon have been commented upon in connection with the floor of the skull. The medulla oblongata is over twice as large as the spinal cord, due to an increased amount of internal gray substance. The **pons** or bridge connects up the hemispheres of the cerebellum across the brain stem, the large cords which enter the cerebellum being known as the brachia pontis. The longitudinal tracts of the brain stem and the transverse tracts of the pons interweave, producing the characteristic elevation of this area. Above the pons the tracts of the brain stem continue into the mesencephalon, the short columnar part of the encephalon, which extends through the opening in the tentorium cerebelli. There is no sharp line of demarcation between the mesencephalon and the diencephalon, but the upper part which divides to enter the cerebral hemispheres, belongs to the diencephalon. The dividing portions of the mes- and diencephalons, distinctly visible

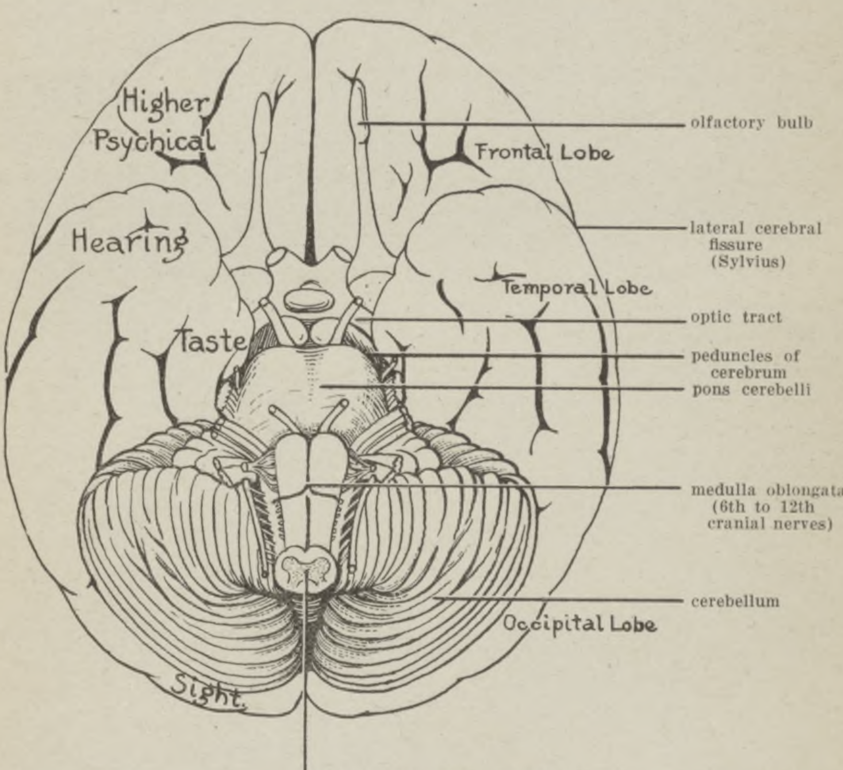


Fig. 93.—Basal surface of **Encephalon.**

from below as large cords, are known as the **pedunculi cerebri** (peduncles = little foot) (O.T. crura cerebri). These peduncles are somewhat overlapped by the temporal lobe of the cerebrum, but by pushing this part aside, they may be freely exposed to view. The mes- and diencephalons have on their upper surfaces masses of gray substance, which belongs mainly to the optic nerves.

The olfactory bulbs should be located on the inferior surface of the frontal lobe and the tracts traced back to their connection with the cerebrum. The optic nerves should be noted to form a junction (chiasm) in the midline in front of the diencephalon, and the optic tracts should be followed towards the upper part of the di- and mesencephalons. The third and fourth nerves arise from the mesencephalon, the fifth from the pons, while the last seven pair take their origin from the medulla oblongata. The cerebral localization of the centers for higher intellect, hearing and sight are continued into the base from the sides. The centers for taste and smell are continued into the base from the falx cerebri surface.

Arteries

The two vertebral arteries are peculiar inasmuch as they join into one basilar trunk, which grooves the pons in the midline. The internal carotid arteries enter the area between the temporal lobes, and send the **anterior cerebral arteries** forward into the falx cerebri fissure. The **lateral cerebral arteries** are practically the continuation of the internal carotids and enter the lateral cerebral fissure of Sylvius between the temporal and frontal lobes. The basilar artery after passing the pons divides into the two **posterior cerebral arteries** which supply the posterior portion of the cerebrum. The vertebral and internal carotid connect up freely by large branches, this anastomosis being known as the **arterial circle** of Willis. In contradistinction to former beliefs, modern work has demonstrated that the terminal branches of the three cerebral vessels also anastomose. Numerous small branches from the circle enter the base of the brain.

The base of the encephalon should be examined.

Midsection of Encephalon

A midline section should be made with one sweep of the knife between the cerebral hemispheres, continuing also through the brain stem and cerebellum. This dissection not only exposes the medial surface of the cerebrum, but also demonstrates much of the interior structure of the whole encephalon. The cut surfaces of each lateral half should be examined, inasmuch as the section practically never lies exactly in the midline. The shaded area of the diagram are the portions of the encephalon sectioned.

The **corpus callosum** is made up essentially of tracts intercommunicating between the cerebral hemispheres, and in this dissection is cut at right angles. It is, therefore, white and to a certain extent earns its title of callous portion. Outside of the corpus callosum lies the medial surface of the hemispheres of the cerebrum, which has around its circumference the overlapping of the localization for the higher intellect, central motion and sensation, and sight. The callosal segment of this medial surface is the central area for the special sense of smell and posteriorly the area for taste. The **fornix**

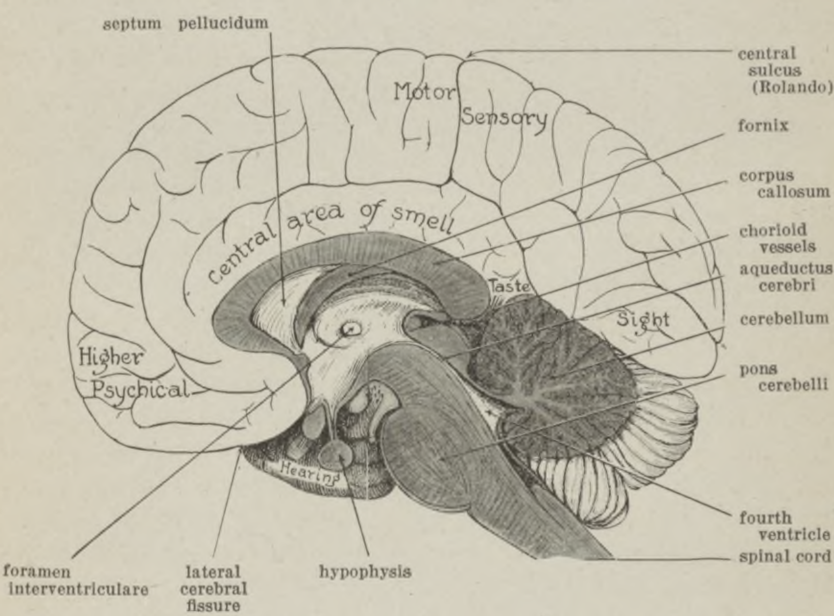


Fig. 94.—Medial surface of **Encephalon**, shaded parts sectioned.

is continuous at both extremities with the corpus callosum, and like it contains tracts interconnecting between the cerebral hemispheres (fornix = vault). Most of its processes run anteroposteriorly connecting up gray areas of the cerebrum, some of these areas being of the same, but others of the opposite, sides. Two other much smaller tracts, which interconnect the halves of the diencephalon, are known as the anterior and posterior commissures.

The fornix forms the roof of the third ventricle, while extending from the fornix to the corpus callosum in the midline is a **septum**

pellucidum. The septum pellucidum, as its name implies, is a thin sheet which forms the partition between the lateral, that is, the first and second, ventricles. The lateral ventricles lie just under the corpus callosum, and should be noted to extend well into the cerebral hemispheres. The third ventricle, which lies in between the two halves of the diencephalon, has the fornix for its roof and a very thin layer for its floor. The infundibulum, or stalk, of the hypophysis attaches to the floor of the third ventricle, which is the foundation for the opinion of some anatomists that the hypophysis is not a ductless gland. The third ventricle on each side anteriorly has a round opening known as the **foramen interventriculare** of Monroe, which connects up the third ventricle with the first ventricle in the right cerebral hemisphere and the second ventricle in the left cerebral hemisphere. A narrow passageway known as the **aqueductus cerebri** leads from the third ventricle down through the mesencephalon to the fourth ventricle (aqueduct = water duct) (O.T. iter of Sylvius). The fourth ventricle lies between the brain stem of the medulla oblongata and cerebellum, and the cerebellar hemispheres proper. Vessels grow into the upper back surface of the third and fourth ventricles, but technically never enter as they are always covered by an epithelial fold (lamina chorioidea epithelialis). The connective tissues surrounding these vessels in their course to the ventricles is technically known as the tela chorioidea ventriculi. The rich vascular network not only lies in the third ventricle, but continuing on each side through a thin portion of the upper part of the wall and through the interventricular foramina enters the first and second ventricles. These chorioid vessels are unfortunately stated to form a plexus instead of anastomosis, which is obviously a very probable source of confusion. The fourth ventricle has a separate series of chorioid vessels, which enter through its roof. The chorioid vessels are branches of the posterior cerebral arteries, while the corresponding veins eventually enter the straight sinus, which courses back in the fold between the falx cerebri and the tentorium cerebelli.

Cerebrospinal Fluid

These chorioid vessels are of great practical importance, inasmuch as they secrete the cerebrospinal fluid. The cerebrospinal fluid in health is perfectly clear and colorless, and normally contains only a few desquamated endothelial cells. It contains practically no nourishment for the cells and practically no waste products, but does contain a sufficient mixture of various salts to raise its specific gravity to about one thousand and six. Pus, lymph, blood, or an increase in endothelial cells in the cerebrospinal fluid are all evidence of an abnormal condition of the encephalon or spinal cord. The cerebrospinal fluid is probably continuously secreted by these chorioid vessels, and probably by no other structures. The fluid passes back through the aqueductus cerebri to the fourth ventricle and there escapes through the medial and lateral apertures between the cerebellum and medulla oblongata into the pia-arachnoidal sac (O.T. foramina of Magendie). Cerebrospinal fluid is normally being constantly absorbed into the lymphatics or capillary veins throughout the whole extent of the pia-arachnoidal sac. The thin-walled, tufted projections into the venous sinuses of the skull are known as the **arachnoidal granulations** of Pacchioni. These structures allow the cerebrospinal fluid to come into intimate contact with the venous blood, the two fluids being separated only by a double layer of endothelial cells. It is generally believed that these bodies have to do with the absorption of cerebrospinal fluid into the blood, but this outflow would probably only occur during such periods as the pressure of the cerebrospinal fluid is higher than that in the veins.

If the lateral and medial apertures of the fourth ventricle or the aqueductus cerebri are blocked, cerebrospinal fluid accumulates in great quantity inside the ventricles. While a few ounces of cerebrospinal fluid is the normal amount inside the ventricles, in a blocked condition the amount may increase to a pint or more. This clinical condition is known as internal hydrocephalus, or water inside the encephalon. If such an increase of cerebrospinal fluid within the ventricles takes place in early childhood, the cranial bones are forced apart and the skull proper becomes bulging and extremely large. As yielding of the adult skull is impossible, the pressure in the adult is exerted on the encephalon, resulting in disturbed nutrition and eventually destruction of the brain cells. Even though the blockade of the ventricle passageways be complete and cerebrospinal fluid accumulates tremendously in the ventricles, a sufficient amount of fluid is formed beyond the blockade or escapes through the weak points of the distended ventricles to keep the pia-arachnoidal sac distended. In clinical cases of great pressure within the skull, the sudden removal of quantities of cerebrospinal fluid via lumbar puncture may result in forcing the medulla oblongata down into the foramen magnum and cause sudden death.

Cerebrospinal fluid must not be confused with the lymph of the nervous tissue, as seems often to be done. Lymph carries nourishment and waste products, whereas cerebrospinal fluid normally contains, practically speaking, neither nourishment nor waste products. The cerebrospinal fluid acts mechanically as a protection to the encephalon and spinal cord, just as the lesser amounts of serous secretion in all endothelial lined cavities. Cerebrospinal fluid is secreted under pressure, consequently the encephalon and spinal cord literally float in the fluid. Lymph is produced by the capillaries in the nervous tissues, and serves its usual function as a carrier of nourishment and waste products. As lymphatic vessels have not been demonstrated leaving the encephalon, it is very probable that the lymph reenters the venous sinuses of the skull via small ducts.

Horizontal Sections

The next section should be carried through the cerebrum on a horizontal plane about one-half of an inch below the top of the corpus callosum. This should be carried through both cerebral hemispheres, and after this section has been examined, another horizontal plane should be sectioned about one-quarter of an inch lower down. The lateral halves should be fitted together in order to obtain a better picture.

Half Inch Below Top of Corpus Callosum

The whole cortex of the cerebrum is covered by a layer of gray substance about one-eighth of an inch in thickness, following down into the grooves and over the convolutions. The falx fissure can be readily made out running down to the corpus callosum both in front and in back. The first and second ventricles, separated by the septum pellucidum, can be noted well opened up and extending well into the occipital and frontal lobes. With the aid of a probe the part of these ventricles turning down into the temporal lobes may be followed out. The ventricles are separated in the middle line by the fornix and the septum pellucidum. Masses of gray substance, known as the **internal or basal nuclei,** lie in the interior of the cerebral hemispheres separated by tracts of white processes. The function of these internal nuclei has not been completely determined, although it is known that they serve as way-stations between the

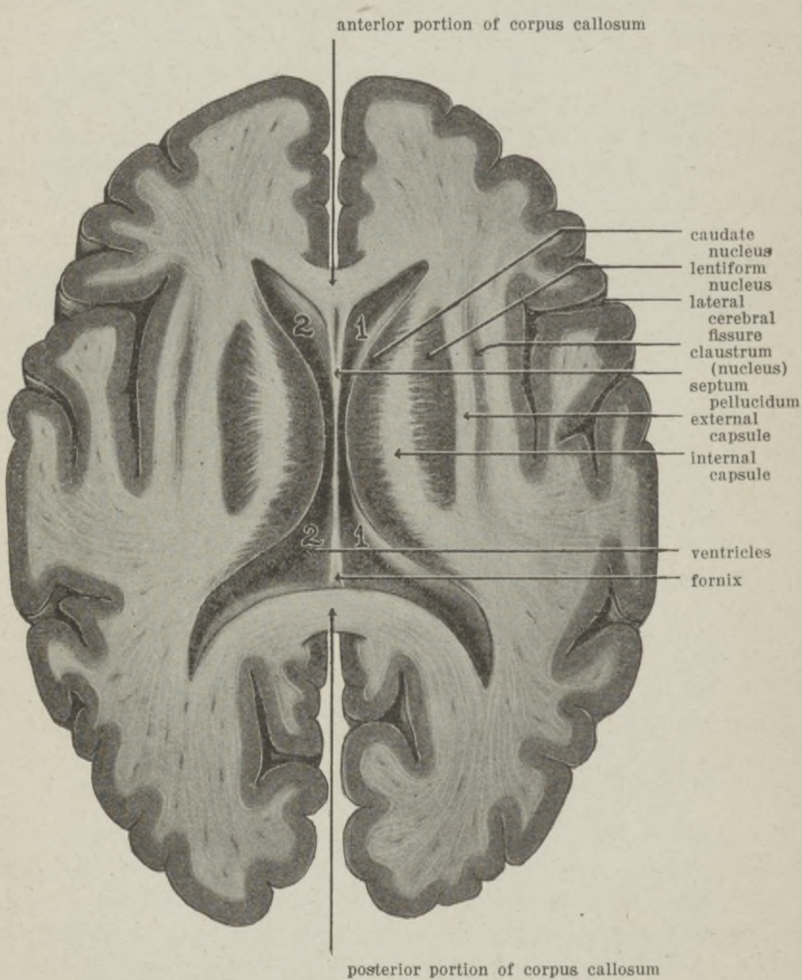


Fig. 95.—Interior of **Cerebrum.** (Horizontal section ½ inch below top of corpus callosum.)

cerebral cortex and the spinal cord. There are also corresponding masses of gray substance in the brain stem, but the question of which cerebral nerve processes stop in these nuclei and how often this process is repeated in the case of individual nerves is not accurately known. The mass of gray substance, which bulges in the lateral wall of the lateral ventricles is known as the **caudate nucleus,** on account of the fact that it terminates in two tail-like projections. Just outside of this nucleus, separated by white substance, lies the **lentiform nucleus,** so named on account of its similarity in shape to a bean. Still further out, and again separated by white substance, lies the thin **claustral nucleus,** the word claustrum stating that it forms a barrier under the sunken island portion of the cerebral cortex. The white strand between the caudate and the lentiform nucleus is known as the **internal capsule,** while that between the lentiform and the claustral nucleus is known as the **external capsule.** These capsule tracts are continued into the brain stem, and, coming together in the mesencephalon, make the prominent pedunculi cerebri, which were noted in the external consideration of the base of the encephalon.

Such processes as intercommunicate between the cerebral cortex and the brain stem are known physiologically as projection fibers; between the two cerebral hemispheres, as commissural, and between neighboring cortical areas, as association fibers.

Three-quarter Inch Below Top of Corpus Callosum

The corpus callosum is cut across near its lowest parts. The fornix is cut across in the midline, and anteriorly shows a small slit, which is now known as the cavity of the septum pellucidum. The roof of the third ventricle is opened up, its side walls being mainly made up of the gray substance of the diencephalon. This mass of cell bodies belongs in the main to the optic nerves and is known as the **thalamus.** The lentiform and claustral nuclei appear in this section, while only the tail tips of the caudate nucleus are to be seen. The thalamus is made up of the peripheral optic nerve cell bodies of the brain stem, which connect up via the optic tracts and nerves with the eye. These optic thalami make central connections with the occipital lobe of the cerebrum, as will be detailed in connection with the detailed study of the eye.

Dissection of Fresh Encephalon

Even though the dissection of the encephalon of the dissecting room body has proved absolutely satisfactory, it is most advisable to supplement this by a dissection of a fresh encephalon from cattle or hogs. The fresh encephalon will show even from the surface examination the marked contrast between the white and gray sub-

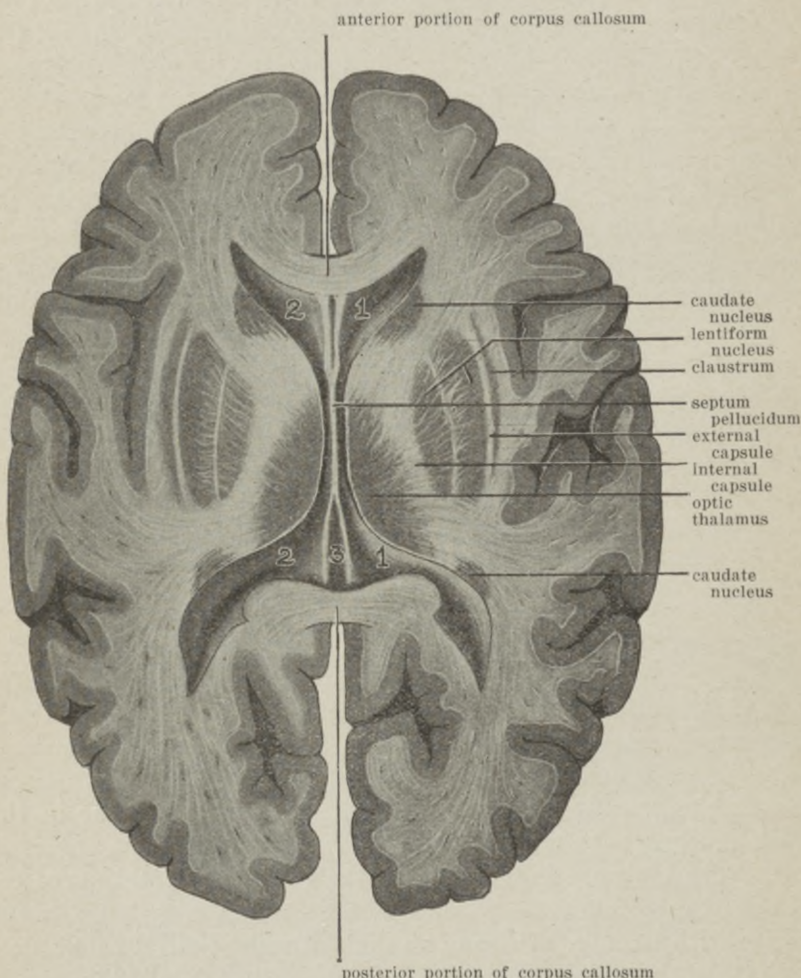


Fig. 96.—**Interior of Cerebrum.** (Horizontal section ¾ inch below top of corpus callosum.)

stances, and will give a just conception of the soft consistency, as noted in connection with the fresh spinal cord. The strength of the peripheral nerves is due essentially to their white, fibrous connective-tissue sheaths, which are not to be found inside of the dura mater.

The chorioid vessels, the corpus callosum, the ventricles and the basal nuclei and their so-called capsules are all readily demonstrable, the colorings and consistency especially being a great improvement over the conditions in any preserved encephalon.

Meningitis

Cerebrospinal meningitis is caused by various types of bacteria attacking the surfaces of the encephalon and spinal cord. It not only attacks the external surfaces, but spreads into the ventricles as well. Meningitis may be secondary to direct spreading infection from the nose or ear, or occurs in association with some general disease as pneumonia or tuberculosis. The epidemic form is caused by a special organism, which some authorities believe spreads from the nose through the cribriform plate of the ethmoid bone. Meningitis is a very possible complication of fracture of the skull, and also occurs via a septic vein clot in connection with head infections. In this disease the cerebrospinal fluid is full of pus, consequently various procedures to drain off the infected cerebrospinal fluid semi-continuously are nowadays being advocated. Secondary blockade of the ventricular passageways is not at all an uncommon sequela of any meningitis.

Hemorrhage

The characteristics of hemorrhage in association with fractures of the skull, and the minute scattered blood effusions in association with severe concussions, have already been discussed. The bursting of an artery inside the skull without trauma is due to degeneration of the vessel wall, and is known clinically as apoplexy. Some of the blood mingles with the cerebrospinal fluid, but the bulk of it forms a firm clot. The lodgment or the formation of a clot in a large cerebral vessel may cause a somewhat similar clinical picture, but without the marked pressure symptoms. There is commonly a partial recovery from smaller hemorrhages, while the very large hemorrhages cause death within a few hours. The symptoms of severe pressure within the skull are stupor, eventually unconsciousness, muscle weakness, eventually paralysis, slow, deep breathing, and a slow, strong pulse. Accurate localization of the clot in sudden serious cases is commonly impossible, but if small in amount, a later examination of the nervous system may allow a fairly good estimate of the pressure position. Inasmuch as the walls of other cerebral vessels are also degenerated, operative measures in apoplexy offer little hope except for temporary benefit.

The diagnosis and localization of brain tumor, abscess or hemorrhage depend upon two distinct sets of symptoms; viz., general encephalon pressure, and local disturbances of the nerve centers and tracts.

General Encephalon Pressure

General pressure symptoms upon the encephalon may be caused by the size of the tumor, abscess or clot. As the encephalon by forcing out cerebrospinal fluid has a decided factor of safety, the tumor, abscess or clot must be at least the size of an egg in order to cause marked general pressure symptoms. Very commonly the general pressure is brought to bear by some form of blockade of the ventricle passageways, resulting in an enormous increase in the intraventricular cerebrospinal fluid, often a pint or more in amount. As noted in connection with hemorrhage, the general symptoms of pressure may be so marked as to obscure all localizing symptoms. In addition to the profound disturbance of the cerebral centers, pressure on the medulla oblongata results in a slow respiration and pulse, and a type of vomiting unassociated with the eating or digesting of food. Further, the pressure on the optic nerves results in a swelling at their entrance into the orbit, which, if maintained, eventually leads to a permanent loss of sight.

Local Encephalon Pressure

Local pressure symptoms can be recognized by a careful examination of all the peripheral nerves, more especially of the cranial group. A motor or sensory disturbance in any part of the body may be referable to an encephalon disturbance. The presence of a normal spinal cord or brain stem reflex in the affected area would tend to exclude peripheral neuron involvement, so that by exclusion the disturbance must be in the central neurons. The earlier in its course a brain disease comes under observation, other things being equal, the easier and more accurate is the diagnosis, and the more favorable the outlook for treatment. It follows, therefore, that the proper diagnosis and treatment of physical nervous diseases depends in great part upon a knowledge of the anatomic structure of the nervous system.

FACE

The face is anatomically that portion of the head which surrounds the eyes, nose, and mouth. The forehead belongs anatomically to the cranium cerebrale, although, popularly, it is considered as a part of the face. The external surfaces of the facial bones are, generally speaking, palpable under the thin layer of face musculature. The face bones developmentally are separated by cartilaginous strips, which persist as the suture lines of the adult skull. The persistence of these suture lines is the justification for considering the facial as separate bones instead of as a single bone.

Face Bones (Ossa Faciei)

The frontal bone, and the part it takes in the formation of the supraorbital margin and the roof of the orbital cavity, has been considered in connection with the calvaria. A pair of **nasal bones** run from the frontal bone to about the midpoint of the nose, forming what is popularly known as the bridge, while the remainder of the facial part of the nose has only a cartilaginous framework. The great size and the forward projection of these bones is the racial characteristic of the Jewish peoples. On the lateral and inferior sides of the orbita, taking part in the formation of this cavity, are the prominent **zygomatic bones** (O.T. malar). Excessive size and prominence of these bones are characteristic of the American Indian and the related (?) Mongolian races. The temporal process of the zygomatic bone meets the zygomatic process of the temporal bone at about the half-way point to form the zygomatic arch. The **maxillas,** or, in the old terminology, the superior maxillas, take a prominent part in the formation of the orbital, nasal and oral cavities. The nasal and zygomatic bones have suture line attachments to the maxillary bones. The **mandible,** or inferior maxilla, is the freely movable lower jaw bone. The ridges projecting out from the bodies of the maxilla and mandible for the insertion of the teeth are known as the alveolar processes. Whereas the suture lines can only be made out by a detailed examination of a skull, the main points noted can be made out by surface palpation.

The nasal and some of the internal bones of the face region as yet unconsidered are classified on developmental evidence as belonging to the cranium cerebrale. The paired maxillas, zygomatic and

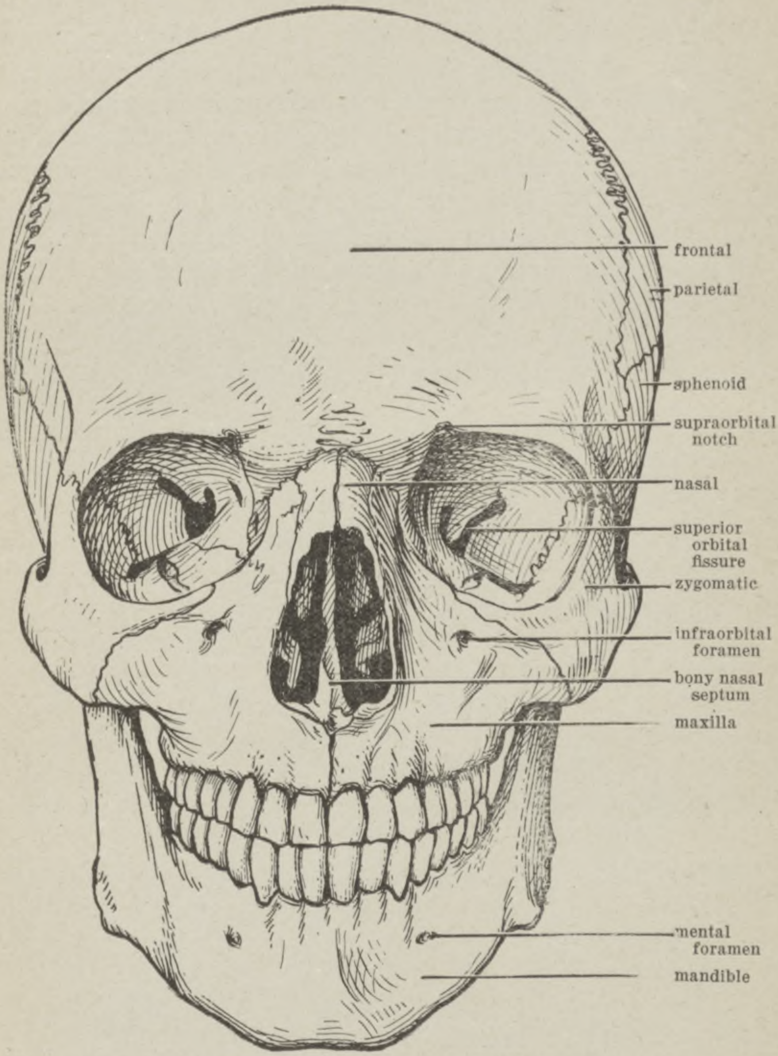


Fig. 97.—Front view of **Skull (Cranium).**

palatable bones and the mandible are both developmentally and functionally parts of the cranium viscerale.

Divisions

The face is made up developmentally of three parts, shown in the adult by the persistence of the ophthalmic, maxillary, and mandibular divisions of the trigeminal nerve. The whole head is probably to be considered as one greatly modified segment even though the lower jaw has a free range of motion. Segmentation is determined by movement, but as the mandible goes only part way back it probably should not be considered as of a separate segment. The growing together in the midline of the three lateral portions of the face is represented by the midline sutures of the frontal, nasal, and maxillary bones. A midline suture exists early in the development of the mandible, but disappears without leaving a trace in the adult.

Skin

The skin is fairly thick over the face, though, of course, this varies with age, sex, exposure and other secondary factors. At the orifices of the eyes, nose and mouth the skin joins the mucous membrane surfaces. The eyebrows (supercilia) with their exuberant growth of hair, are a special shade protection for the eyes. The presence of a great amount of hair over the beard area is characteristic for the adult male, while other portions of the face in both sexes normally have only very fine hair. A very characteristic feature of the skin of the face is the insertion of many voluntary muscles into the deep surface, when in action giving rise to changes in expression and dimples. The area of higher color over the cheeks is anatomically characterized by a thinner skin.

The skin should be dissected off.

Subcutaneous Fatty Layer

This layer varies in thickness with the general stoutness of the individual. On account of the delicate character of the deep fascia over the small facial muscles, and the insertion of many of these muscles into the skin, the distinction between the subcutaneous fatty layer and the deep fascia is not easy to keep clear. Cutaneous arteries, veins, nerves, and the superficial venous system are to be found in this fatty layer, while the main arteries and veins lie under the deep fascia.

Muscles of Eye Group

The **orbicularis oculi** muscle, as its name indicates, encircles the eye. It is a wide, thin sheet arising from the bones opposite the medial angle of the eye and inserting opposite the lateral. Part of this muscle extends down into the eyelid, which portion of the muscle is called the orbicularis palpebræ (palpebra = lid). Contraction of the palpebræ portion closes the lids, while the other portion of the muscle draws in the surrounding skin areas.

The **procerus** muscle arises from the bridge of the nose and attaches to the skin between the eyebrows. It helps the frontal bellies of the epicranius muscle to draw down the eyebrows and is used in the familiar scowling appearance of displeasure.

Muscles of Nasal Group

The **caput angulare** of the quadrate muscle of the upper lip arises from the frontal process of the maxilla and inserts into the lateral cartilaginous wall of the nose. This is the main dilator muscle of the nostrils, which comes markedly into play whenever breathing is exaggerated from any cause whatsoever.

The openings of the nostrils onto the face are normally much the narrowest part of the nasal cavities, hence this dilation lessens the resistance to the inflow of air. A tinge of blueness of the individual and exaggerated action of these dilator muscles is very characteristic of the various pneumonias. The cartilage tends to spring back into place whenever the muscles relax, but there are in addition some constrictor muscles of minor importance.

Muscles of Oral Group

The **orbicularis oris** muscle forms a voluntary sphincter muscle of the inlet of the mouth cavity. The following muscles run into it and blend with it:

The **quadratus labii superiores** muscle arises from the maxilla just below the orbital cavity and from the zygomatic bone and inserts into the upper lip.

The **canius** muscle arises from the maxilla deep to the quadratus labii superiores origin and inserts into the angle of the mouth.

The **triangularis** muscle arises from the body of the mandible, and, converging upwards, inserts into the angle of the mouth.

The **quadratus labii inferiores** muscle arises from the mandible near the midline, partly underneath the triangularis, and inserts into the lower lip.

The **buccinator** muscle runs from the ligament extending between the posterior parts of the upper and lower jaws to the orbicularis muscle, extending between the bases of the alveolar processes of the maxilla and mandible. This cheek muscle, which lies close to the mucous membrane, is popularly known in connection with whistling and the blowing of wind instruments.

The platysma muscle arises over the lower part of the face and extends down across the neck, controlling the skin movements. The risorius is a slip of the facial part of the platysma, which inserts near the angle of the mouth into the skin, producing a dimple on contraction. The zygomaticus runs downward from the temporal process of the zygomatic bone into the skin near the angle of the mouth. The mentalis arises from the mandible and inserts into the skin over the chin.

The facial muscles should be dissected.

Blood Supply

The **external maxillary** or facial branch of the external carotid artery crosses the mandible about its midlateral point. The artery runs diagonally upwards and medially past the angle of the mouth, sending off inferior and superior labial branches. It passes close to the wings of the nose, sending off lateral nasal branches, and terminates near the medial angle of the eye. The artery is somewhat coiled when the mouth is shut, but is straightened out when the mouth is fully open. The facial vein and lymphatics in general correspond to the artery, and empty into both the superficial and deep jugular veins, and corresponding lymphatic glands. The artery and vein as usual take as deep and protected a position as possible, but in this case they necessarily lie not far from the surface.

Motor Nerve Supply

The **facial,** the seventh cranial nerve, should be located at its point of exit from the temporal bone. It appears through a foramen in the base of the skull, half way between the mastoid and styloid processes, which is therefore known as the **stylomastoid foramen.** The nerve turns sharply forward under the parotid gland and divides into radiating branches, which supply all the muscles of the face.

Sensory Nerve Supply

The ophthalmic division of the fifth, or **trigeminal nerve,** leaves the interior of the skull via the superior orbital fissure, the maxillary through the foramen rotundum, and the mandibular through the foramen ovale. Most of the branches of these nerves traverse canals through the facial bones in their course towards the skin.

The ophthalmic division sends out as its main trunk the **supraorbital nerve,** which supplies the frontal portion of the scalp. Small palpebral branches run to the lids and a separate small branch supplies the bridge of the nose.

The maxillary division sends out as its main branch the **infraorbital nerve,** which leaves the maxillary bone just below the orbital cavity at the junction of its intermediate and medial thirds. This large nerve supplies the lower part of the nose, the upper lip, and part of the cheeks. A small zygomatic branch goes through a separate bony canal and appears over the cheekbone.

The mandibular division sends a **mental** branch to the skin through a foramen approximately an inch lateral to the midline. A small buccinator branch supplies the skin over the lateral mandibular area.

These vessels and the sensory nerves should be cleared.

Orbital Cavity (Orbita)

The bony wall of the orbital cavity is a cone-shaped space with its widest part at the facial surface. The depth at which the eyeball is set in the socket varies, but the eye is normally well protected by the projecting supraorbital margins, zygomatic and nasal bones. At the small posterior end of the orbital cone lies the superior orbital fissure, through which the ophthalmic vein and most of the nerves enter the cavity. The optic nerve runs through a separate foramen in the lesser wing of the sphenoid bone. The bony walls of the orbital cavity are all thin sheets covered on both surfaces, as would be anticipated, by periosteum. The roof of the orbital cavity is the orbital part of the frontal bone, while the floor is made up chiefly by a plate of the superior maxilla, supplemented in its front lateral part by the zygomatic bone. The zygomatic bone forms the anterior part of the lateral wall, while posteriorly the greater wing of the sphenoid forms its section of the wall. The medial wall is made up mainly by the ethmoidal labyrinth (O.T. lateral mass) which intervenes between the orbital and the nasal cavities. The small lacrymal bone intervenes between the anterior border of the ethmoidal labyrinth and the posterior border of the frontal process of the maxilla, completing this medial bony wall.

Eyelids (Palpebræ)

The firm connective tissue framework in the interior of each lid is known as the **tarsus.** The tarsal plates are shaped to conform with the globular surface of the eye, and are attached by medial and lateral ligaments to the maxillary and zygomatic bones, respectively. As the upper lid is much larger than the lower, the upper tarsus is also larger than the lower. The medial and lateral tarsal ligaments serve as points of origin and insertion for the palpebral portion of the orbicularis oculi muscle. The skin over the eyelids is extremely delicate. The eyelashes are a protecting mechanism of the eye and are arranged in regular order along the lid margins. Pulling the eyelid off the eyeball by means of traction on the eyelashes will show along the lid contact margin the mouths of a modified type of sebaceous glands, which are known as the tarsal glands of Meibomi. If the lid be everted these glands can be noted as parallel yellow streaks extending well into the tarsus. The small round opening (puncta lacrymalia) in the upper and lower lids near their medial angle is the beginning of the **lacrymal,** or tear, **duct.** The lids are made up of the skin, subcutaneous fatty layer, deep fascia, orbicularis palpebræ muscle, then the tarsus, and internally the mucous membrane.

Conjunctiva

The mucous membrane covers not only the inner surface of the lids, but also the outer surface of the eyeball, and is therefore called the conjunctiva. The **lacrymal glands** lie back of the upper lid under the lateral third of the orbital plate of the frontal bone. These glands are only incompletely separated from each other, the whole structure averaging about one-eighth times one-quarter times one-half inches in diameter. They are of typical glandular structure and pour their secretion into the upper lateral portion of the conjunctival sac through many small ducts. The secretion serves to keep the surface of the eye washed and is pumped by movements of the lids into the lacrymal ducts, which will later be noted to empty into the nose.

When the lacrymal ducts are partially blocked or when there is an extra quantity of lacrymal secretion as in crying, the tears run down over the surface of the face. Conjunctivitis may be a primary disease, or it may be secondary to infection spreading through the lacrymal ducts from the nose.

As some of the finer markings are lost in a dissecting room body, the student should examine his own lids by means of a looking glass, or examine his fellow-student's lids. Then the lids and the lacrymal sac should be dissected.

Orbital Fascias

The eyeball (bulbus oculi) is held in position by layers of fascia as would be expected. The fascias surrounding the eyeball are connected up with those lining the orbital cavity by many sheets of very complicated detail arrangement. For general purposes the statement suffices that the arrangement is such as to hold the eyeball steady against up and down, side to side, or front and back movements. The fascia bundles running between the medial and lateral tarsal ligaments under the eyeball in a hammock-like arrangement have to withstand gravity pull and are consequently stronger than the rest. This portion is often referred to as the suspensory ligament, which obviously would have great surgical importance. The fibrous capsule of the eyeball is known technically as the **fascia bulbi** of Tenon. This fibrous capsule does not differ essentially from the extrinsic capsule of other organs, except that it does not surround the anterior portion of the globe of the eye. A serous sac as a friction reducer between this outer fibrous capsule and the outer coat of the eyeball would be the logical expectation. But most investigators have considered the sac, which encloses the posterior half of the eyeball, to be a lymph space. As both a lymph space and a serous sac are lined by endothelial cells, so that anatomically there is no possible distinction, it seems much more reasonable to consider this a serous sac.

The dissection of this fascia capsule must be postponed until a later stage of the work.

Muscles (Musculi Oculi)

The four **rectus oculi muscles** arise about the superior orbital fissure and run straight forward to their equidistant distribution about the equator of the eye. These muscles, named, according to their position **superior** and **inferior, medial** and **lateral,** act without pulling the eye deeper into the orbita because of the resistance of the fascia bulbi of Tenon. The internal rotator muscle of the eye, known as the **superior oblique,** arises in common with these muscles, but turns through a pulley in the upper medial part of the orbital bony wall. The external rotator muscle of the eye, known as the **inferior oblique,** arises from the medioinferior bony wall opposite the equator of the eyeball. A special elevator of the upper eyelids, the **levator palpebræ superiores,** also arises from the common tendon, and, running forward just under the orbital part of the frontal bone, spreads out for its insertion into the upper lid.

The superior oblique is supplied by the fourth, or trochlear nerve and the lateral rectus by the sixth, or abducent nerve. All the other voluntary muscles of the orbital cavity are supplied by the third or oculomotor nerve.

Sensory Nerve Supply

The **ophthalmic division** of the fifth cranial nerve enters the eyeball by many branches, giving a liberal sensory supply to the various coats. Other branches of this division of the nerve run in grooves or canals of the bony wall, supplying the bone and eventually terminating on the face. The supraorbital and palpebral branches have previously received sufficient consideration. The nasal branch tunnels the ethmoidal labyrinth and supplies the upper part of the nasal cavities before emerging from its canal on the anterior surface of the nasal bones.

Vessels

The **ophthalmic artery** is a branch from the internal carotid, which runs directly forward through the optic foramen into the orbital cavity (orbita). This artery supplies the bony walls, the fat, and the muscles, and enters the eyeball by a number of branches. Terminal twigs of the ophthalmic anastomose with the external maxillary at the medial angle of the eye. The ophthalmic vein is made up of corresponding branches and entering the skull through the superior orbital fissure becomes the cavernous sinus.

Obstruction of the cavernous sinus will, and semiobstruction of the large veins nearer the heart may, produce an overdistention of the ophthalmic veins with a secondary edema. This pressure in back of the eye gives the clinical picture of exophthalmos, the bulging forward of the eyeball. Exophthalmos might also be produced by the growth of tumors, abscesses or arterial hematomas in back of the eyeball. The reverse picture of enophthalmos would be produced by a decrease in the amount of orbital fat, or acutely when the orbital vessels are less distended, as in shock, severe hemorrhage, or any severe water abstraction from the body. The lymphatics of the orbita follow the ophthalmic vein and eventually connect up with the deep lymphatic glands of the neck. Sympathetic nerves from the superior cervical ganglia follow the branches of the ophthalmic artery into the eyeball, controlling part of its blood supply and some of the involuntary musculature.

Optic Nerve (Nervus Opticus)

The optic nerves may be traced through the optic foramen of the lesser wing of the sphenoid bone to their entrance just medial to the posterior pole of the eyeball. The nerve eventually terminates in the inner coat of the eye in end processes, which serve to gather up the light impulses. If the crossing of the optic nerve processes were complete where they come into contact with each other, each cerebral center, mass of brain stem nuclei, and tract would control the opposite eye. This point of contact and decussation of the two optic nerves is known as the **optic chiasm.** But the actual arrangement differs from this theoretical probability, inasmuch as the decussation involves only the nasal half of each tract. Each cerebral center, series of brain stem nuclei, and tract, as a matter of fact, controls its own side half of both eyes. Thus the right occipital cerebral center, for example, controls the right, or temporal, side of the right eye, and right, or nasal, side of the left eye. A loss of sight due to a disturbance in the eye or optic nerve can therefore be readily distinguished from a loss of sight due to disease in the optic tract, brain stem nuclei, or cortical center.

Dissection.—A demonstration of the orbital cavity structures may be best obtained by chipping out from above the central part of the orbital plate of the frontal bone. The periosteum is ordinarily shoved off by this dissection from the under surface of the orbital plate and consequently will have to be split in order to get at the orbital muscles, vessels, and nerves. The loose fatty tissue should be freely removed in order to clear these structures.

Fibrous Coat of Eye (Tunica Fibrosa Oculi)

The very tough fibrous outer coat of the eyeball, known as the **sclera,** protects the delicate interior structures of the eye. The sclera normally shows as a deep white through the conjunctiva, being made up of matted bundles of white fibrous connective tissue. Around the anterior pole of the eye the sclera is replaced by the **cornea,** which is necessarily transparent on account of the function of the eye. The cornea proper is a specially modified connective tissue layer, somewhat comparable to cartilage in structure, as it has corpuscles lying in spaces connected up by canaliculi for the lymphatic circulation. After birth the cornea normally has no arteriovenous supply, while if a section be removed, it is replaced by white fibrous scar tissue and not by transparent corneal tissue. The layer of conjunctival epithelium over the cornea is without pigment even in its basal cells, which is a striking phenomenon as the ordinary living body cells are very susceptible to the injurious influences of sunlight, and are protected by pigment. The cornea makes the segment of a much smaller circle than the sclera, as is shown in the diagram. The sclera is thicker posteriorly and, although varying somewhat with the physical vigor, is really much stronger in all individuals than popularly conceived.

Chorioidea and Retina

The interior lining of the eye is the **retina,** which contains the end structures of the optic nerve. This layer is thicker and functionally most important at the posterior pole of the eye, gradually thinning out towards the equator, eventually disappearing. The retina is a very delicate layer and is firmly attached to an extraretinal chorioid coat (tunica vasculosa oculi). The chorioidea is made up essentially of the arteries, veins, lymphatics and nerves, which supply the retina, plus some incidental connective tissue. A layer of black pigment in the deeper layers of the retina serves to prevent false reflections in the dark room portion of the eye. The combined retina and chorioid layers are thin, delicate sheets, in marked contrast to the strong sclera. The retina itself is of a greyish color due to the mass of nerve terminal structures, but has a central, avascular

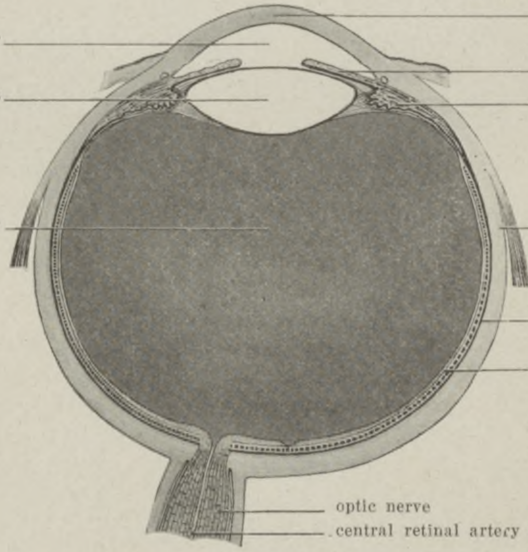


Fig. 98.—Diagrammatic horizontal section of **Eye (Oculus)**.

yellow spot (malcula lutea), which is the area of sharpest vision. The optic nerve enters through a cribriform area of the sclera slightly to the medial side of the posterior pole. The central retinal artery enters at this point and spreads out in chorioid branches for the supply of the retina. The veins of the eye correspond, generally speaking, to the arteries.

Hemorrhages of the chorioidal arteries may force the retina from its attachments to the interior of the eyeball, and may break through into the fluids of the eye. These hemorrhages may be due to a local disease or accident, or to a general arterial wall degeneration.

Crystalline Lens

The crystalline lens is a biconvex, transparent, noncellular disc, which is held in position by a capsular ligament and muscles. When as a hereditary anomaly, or through disease, this lens becomes opaque, the condition is known clinically as cataract. The muscles and ligaments of the lens are attached to the internal surface of the sclera, at about the sclera-corneal junction. The **ciliary muscle** arises from the sclera and inserts into the capsular ligament of the lens, consequently when this muscle contracts, it produces a change in the shape of the semielastic lens. The normal lens at rest is focused for distant sight, while the ciliary muscle changes the shape of the lens for focus on objects closer up.

Iris

The iris musculoligamentous diaphragm lies just in front of the lens, and serves to regulate the amount of light entering the interior of the eye. The pigment normally present in the iris varies with the general fairness or darkness of the individual, and serves to make the iris curtain lightproof. The pink-white iris of the albinos is due to the fact that the muscles and ligaments of the iris are not hidden by pigment. The iris has a sphincter muscle, while it is still open to question as to whether there is also a radial musculature arising from the sclera. These radial strands may well be of elastic fibers, for, clinically, when the sphincter muscle relaxes as in shock or just before death, for example, the pupil characteristically dilates. The sphincter muscle can vary the opening in the center of the iris, known popularly as the pupil, from a pinpoint size to an opening equal to the full extent of the cornea. The normal iris diaphragm contracts when the eye is subjected to a bright light and dilates in darkness so as to equalize the amount of light entering the eye. The pupil appears black because we are looking from the brighter outside into a relatively dark chamber. If a beam of light is thrown through the dilated pupil and the observer's eye looks along the center of this beam, then the pupil and the interior of the eye appear reddish. This is the principle of the ophthalmoscope. The iris and the ciliary musculature are both of the plain involuntary type, and are controlled automatically. The afferent nerves of the iris run in the optic nerve to the thalamus region of the brain stem, while the efferent are contained in the oculomotor nerve. The iris is also connected via branches along the internal carotid and ophthalmic arteries with the superior cervical ganglion. The ciliary muscle enervation runs in the oculomotor nerve, but it has no afferent root. This is the anatomic explanation as to why the disease locomotor ataxia characteristically destroys the iris light reflex, but does not affect accommodation.

The chorioidea continues forward to the ciliary and iris muscles, carrying the vascular and a motor and sensory nerve supply to these parts. The anterior and posterior ciliary arteries pierce the sclera, being regularly arranged around the circumference. and being named on account of their relationship to the equator of the eyeball. These ciliary arteries and the corresponding veins are accompanied by small nerve twigs from the ophthalmic division of the trigeminal nerve.

Humors

The globe of the eye behind the lens and its suspensory ligament is kept distended by the transparent semifluid **vitreous body,** while the area in front of the lens and its suspensory ligament is distended by the clear watery **aqueous humor.** An endothelial lining surrounds both the vitreous and aqueous humor chambers.

Not all of the details in regard to the secretion of these fluids are known, but clinically if the normal outflow into certain lymph channels is obstructed, pressure within the eyeball becomes very high. The main humor outflow presumably escapes into the sinus venosus scleræ (O.T. canal of Schlemm), which makes a circle at the sclerocorneal junction. The finer passageways from the anterior chamber into this venous sinus are not readily determinable anatomically, but clinically following an attack of iritis there is always danger that they will be blocked. This disturbance is known as glaucoma, and if the intraocular pressure becomes and remains sufficiently high, it necessarily interferes so greatly with the blood supply of the retina as to cause loss of sight. Therefore, although some of the anatomic details are still to be demonstrated, it seems fair to assume that these fluids of the eye are being constantly secreted and reabsorbed.

Dissection.—The humors commonly evaporate out of the eyeball in a dissecting-room body, consequently the appearance is very abnormal. However, the eyeball should be dissected, as in spite of appearances many of the main points are to be made out. The eye should be removed from the body by cutting the optic nerve, the extrinsic muscles, and the smaller arteries, veins, and nerves. The fascia bulbi of Tenon is readily to be seen, and by incising it the smooth endothelial sac between this capsule and the eyeball may be made out. The muscle tendons should be traced to their attachment to the sclera. Then the eyeball should be split open with one sweep of the knife from its anterior to its posterior pole. The thickness of the sclerocorneal coat should be noted to be in marked contrast to the blended retinal and chorioid coats. The size and shape of the crystalline lens will be found normal, even though its consistency and transparency is altered. The black pigmentation of the deeper layers of the retina and of the posterior surface of the iris diaphragm should be noted.

If a fresh eye from cattle or hogs is available, a simple sectioning will demonstrate most of the anatomic points noted very satisfactorily.

Mandible Region (Mandibula)

The mandible is the freely movable lower jaw bone. It is throughout most of its extent subcutaneous, or submucous, consequently its outlines can be made out readily from the surface. The bone is developed from two lateral halves which meet in a midline suture, but these halves fuse early in life into one solid piece leaving no trace of the original condition. The heavy square type of mandible is found in people of great physical vigor, and is with considerable justification popularly considered to be associated with mental stamina. The mandible is obviously very exposed to injury so that even though it is extremely strong, fractures are common. Inasmuch as the mucosa of the gums is firmly attached to the bone, these fractures are practically always open for the passage of infectious material into the break.

The horseshoe-shaped portion of the mandible is known as the **corpus,** while the upward extending projections at the posterior ends of the body are known as the **rami.** The large, wide, rounded surface for articulation with the temporal bone is the **condylar process.** The thin sharp projection in the front part of the ramus, known as the **coronoid process,** is raised up by the attachment of the temporal muscle. The mandibular canal is the passageway for the vessels, nerves, and lymphatics through the interior of the mandible. Small branches from this canal exist for the passage of vessels and nerves into the pulp cavity of the teeth. The branches from the inferior alveolar vessels and nerves through the mental foramen have been considered in connection with the face region.

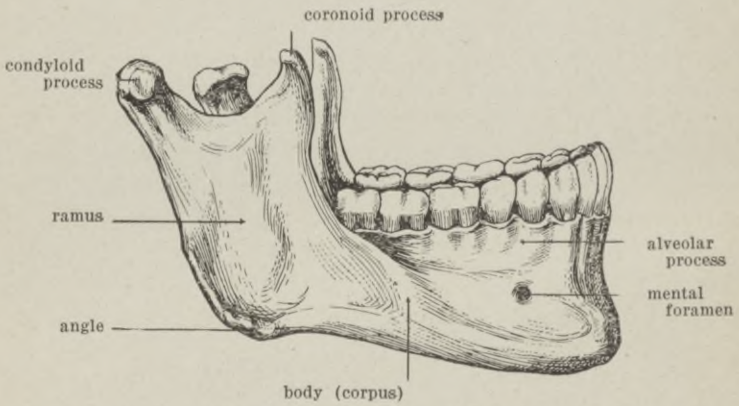


Fig. 99.—Lateral view of **Mandible.**

Teeth (Dentes)

Before the teeth erupt and after they are lost, the mandible closes further and therefore protrudes the chin. The teeth have a very hard bone-like core known as **dentin** (substantia eburnea), and are covered by a still harder ectodermally derived **enamel** (substantia adamantina). The dentin has canalicular spaces connecting the cells, and is cared for by the circulation and nerves of the tooth pulp, while the enamel rods are held together and in place by a small amount of connective tissue material. The teeth are highly specialized structures, and if injured or destroyed, neither the dentin nor the enamel are replaced. The portion of the teeth normally within the gum is covered by a bony layer known as **cementum** (substantia ossea), which is held to the alveolar process of the jaw by a cartilaginous suture line. This cartilaginous strip persists throughout life and, in so far as it yields, acts as a protection for the teeth against fracture.

The temporary, or so-called milk teeth, are two incisors, a canine or cuspid, and two molars for each quadrant of the jaw. Inasmuch as these teeth are too small for the requirements of the adult and possess no mechanism for growth, they are cast off and the permanent teeth grow into place. The permanent teeth are two incisors, a canine or cuspid, two premolars or bicuspids, and three molars in each quadrant.

The teeth should be examined in position and may then be extracted.

Parotid Gland (Glandulæ Parotis)

The parotid is the salivary gland, which lies mainly over the lateral surface of the ramus of the mandible. The gland is held in position by fascias, the main part filling in the space between the front of the ear and the back of the mandible. It never extends upward above the zygomatic arch, but does extend for about half an inch down into the neck region. The parotid gland sends its ducts straight forward from its thin anterior edge to empty into the buccal mucous membrane opposite the second upper molar tooth. The continuation of the external carotid artery runs on the deep surface of this gland and divides about opposite the mastoid process into its terminal internal maxillary and superficial temporal branches. The facial nerve, en route from the stylomastoid foramen to the face, spreads out in the posterior capsule of the parotid into its main subdivisions.

Epidemic parotitis, or, popularly, mumps, must be carefully distinguished from deep abscesses in this region inasmuch as the treatment varies with the diagnosis. Many so-called parotid tumors arise in reality from the remains of the first fetal gill.

The parotid gland should be cleared and then the vessels and the facial nerve should be demonstrated.

Muscles of Mastication

The four positive muscles of mastication are the masseter, the temporal, and the external and internal pterygoids (pterygoid = wing-like process of sphenoid bone). These muscles arise from the skull and insert into the mandible. A branch from the facial nerve nucleus of the brain stem makes its exit through the foramen ovale in company with the mandibular division of the trigeminal, carrying the motor supply to this group of muscles. Branches from the internal maxillary artery, vein and lymphatics supply this area.

The **masseter** arises from the lower edge of the zygomatic arch and inserts onto the lateral surface of the mandible near the angle, that is, its posteroinferior portion. It acts as a powerful elevator of the mandible.

The **temporal** arises from a wide area over the side of the skull and converges on a tendon, which passes under the zygomatic arch to its attachment to the coronoid process. It is a powerful elevator of the mandible.

The main points in regard to these muscles can be made out from the surface, when the lower jaw is in action.

The external and internal pterygoids can only be seen after the masseter muscle has been resected and a portion of the ramus of the mandible between the body and the condyloid process has been sawed out. The ramus should be sawed across near its junction with the body, while the condylar process should be divided about one-quarter of an inch below the temporomandibular joint. The loose segment of the ramus should be removed, which dissection exposes the internal maxillary region.

The **external pterygoid** arises from the lateral surface of the lateral pterygoid plate of the sphenoid bone and from the maxilla, and converges straight backward to its attachment to the mandible just below the condyloid process. It, therefore, acts as a protruder of the lower jaw.

The **internal pterygoid** arises from the medial surface of the lateral pterygoid plate of the sphenoid and from the maxilla, and runs downward, backward, and lateralwards to its attachment on the medial surface of the mandible near the angle. It, therefore, acts as a combined elevator and adductor of the mandible.

When all four of these muscles are acting together, the typical grinding movement of the opposed molar teeth is produced. The depressor muscles of the lower jaw, previously considered in connection with the neck dissection, oppose these elevators.

These muscles should be cleared.

Mandibular Joint

The temporomandibular joints are formed by the well-rounded heads of the mandible fitting into sockets of the temporal bones just in front of the external ear canals. A fibrocartilaginous disc attached to the inner surfaces of the capsular ligament separates the synovial cavity of this joint into two distinct cavities. The capsular ligament is strong but rather lax, consequently dislocation is relatively common. The strength of the joint depends more upon the powerful muscles than upon the ligaments.

The temporomandibular joint should be dissected, noting especially the fibrocartilaginous discus articularis.

Vessels and Nerves

The **inferior alveolar** or dental branch of the mandibular nerve passes straight from the foramen ovale to the mandibular canal. This inferior alveolar nerve and its accompanying artery and vein send a branch into the pulp cavity of each tooth, while the exit of the mental branch onto the chin has been detailed in connection with the consideration of the face. An anterior **auricular** or **temporal** branch of this mandibular division accompanies the vessels of the same name over the temple region of the scalp. At first glance this seems a peculiar distribution for this nerve, but the fact that the temporal muscle belongs functionally to the lower jaw brings this distribution into accord with the general rule. The other large branch of this mandibular division of the trigeminal, known as the **lingual,** turns forward to supply the mucous membrane of the floor of the mouth and tongue.

The external carotid artery just above the angle of the jaw sends the large **internal maxillary** branch forward through the middle of the space. The important downwardly directed branch of the internal maxillary is the **inferior alveolar** or dental artery, while the important upwardly directed vessel is the **middle meningeal.** The middle meningeal runs straight to the foramen spinosum just in back of, and lateral to, the foramen ovale. The internal maxillary artery supplies the muscles of the area and then runs forward to supply the maxillary bone, including the nose. The veins and lymphatics correspond to the arterial arrangement.

These vessels and nerves should be cleared.

Submaxillary Region

The submaxillary region, down to the depth of the mylohyoid muscle, has been considered in connection with the neck. The skin, subcutaneous fatty layer with its platysma muscle and the deep fascia require no special review. The digastric muscle then comes into view, marking off the digastric or submaxillary minor triangle. The floor of this triangle is formed by the diaphragm-like mylohyoid muscle, which runs from the hyoid bone to the inner surface of the mandible around its whole body. This **mylohyoid** muscle may act as an elevator of the hyoid bone or as a depressor of the mandible according to requirements. It is supplied by the branch of the facial, which also supplies the four large muscles of mastication, and certainly acts as an opposing depressor to steady the jaw during mastication.

The submaxillary salivary gland lies in the digastric minor triangle, held in position by fascial layers. It is roughly one-quarter times one-half times one inch in diameter, and, besides the saliva, pours out some mucous secretion. The facial vessels run through a deep groove in this gland, which fact serves as a guide in determining its position. The submaxillary duct of Wharton turns around the posterior border of the mylohyoid muscle en route to the frenulum of the tongue.

The mylohyoid muscle must be divided and turned aside in order to follow out this duct and to obtain a view of the tongue muscles.

The **hyoglossus** muscle is a thin, flat sheet arising from the hyoid bone and running into the sides of the tongue. On its lateral surface in order from above downwards lie the lingual nerve, the submaxillary duct, and the hypoglossal nerve. The lingual artery and vein enter the tongue by passing deep to this hyoglossus muscle. The small **styloglossus** muscle runs from the long styloid process of the base of the skull to the lateral posterior portion of the tongue. The **geniohyoid** muscle arises from a tubercle near the midline inner surface of the mandible and inserts into the hyoid bone. The **genioglossus** lies on a deeper plane, has practically the same origins and insertions, but sends the great bulk of its fibers into the tongue.

The vessels, nerves, and muscles of this area should be dissected.

Interior of Mouth (Cavum Oris)

The mouth is the first portion of the alimentary tract. The lips with their musculature form the opening onto the face, while posteriorly the **isthmus of the fauces** with its musculature separates the mouth from the oropharynx. The mouth is lined by a stratified squamous epithelium derived from and continuous with the ectoderm, the pink color of the lips being due to a lack of the dermis layer. When the teeth are in position and the jaws closed, the mouth is divided into an extradental or buccal cavity, and in intradental cavity or mouth proper. The muscular tongue projects from the floor of the mouth, its tip being held down by connective tissue strands covered by mucous membrane known as the **frenulum** (diminutive check-rein). The openings of the submaxillary gland on the frenulum should be noted. The almond-shaped **sublingual glands,** which pour out a mucous secretion via many small ducts, may be seen spreading out to each side just under the mucous membrane.

Roof of Mouth

The roof of the mouth proper is made up of the **hard** and **soft** palates. The bony framework of the arching hard palate belongs to the maxillary and palatal bones, while the soft palate contains no bone. The horizontal parts of the **palatal bones** form the posterior quarter inch of the hard palate, while the perpendicular parts will later be noted to form a portion of the lateral wall of the nose, being wedged between the maxilla in front and the medial pterygoid plate of the sphenoid behind. Developmentally at an early period the mouth and nose are one single cavity. The palatal processes of the maxillary and palatal bones later grow medially and normally meet the lower part of the septum of the nose. When through a congenital defect these bones fail to meet the bones of the nasal septum, the resulting deformity is known as cleft palate. The hare or rabbit type of lip deformity is very commonly associated with cleft palate. These deformities may be unilateral or bilateral, slight or very great. The presence of severe palatal clefts interferes seriously with the function of the mouth, inasmuch as food and drink can not be forced back properly into the pharynx, but flow outward through the nose. The roof of the mouth is supplied by branches of the maxillary division of the trigeminal nerve, and branches of the internal maxillary arteries, veins, and lymphatics.

Soft Palate (Palatum Molle)

The soft palate continues the hard palate backwards for about an inch and a half, and when raised up by muscular action, separates the nasopharynx from the oropharynx. The elevator muscle of the soft palate will be considered in connection with the nasopharynx. The depressor muscles of the soft palate raise up two folds, formerly known as the anterior and posterior pillars of the fauces. The anterior muscle band is the glossopalatine, while the posterior is the pharyngopalatine, therefore these pillars are known in the B. N. A. as the **arcus glossopalantinus** and the **arcus pharyngopalantinus.** These muscles form a true constriction, hence the term isthmus of the fauces. The median posterior tit-like projection of the soft palate is the **uvula.** A pair of small muscles, which arise from the posterior margin of the palatal bone near the midline, control the elevation of the uvula. Between the faucial arches lie the **palatine tonsils,** aggregations of lymphatic tissue in the mucosa. These tonsils will later receive detailed consideration in connection with the nasopharyngeal tonsil. The motor supply of the soft palate is from the facial and from branches of the vagus, while the sensory supply comes from the maxillary division of the trigeminal.

The vessel supply is from descending branches from the internal maxillary, ascending branches from the pharyngeal, and anastomosing branches which leave the external maxillary in the neck.

If the soft palate is paralyzed or destroyed by disease, on attempting to swallow, food or water will be forced out through the nostrils. If the soft palate is held up in speaking the laryngeal voice sounds can not reverberate through the nose chambers and the voice acquires a so-called nasal twang.

Tongue (Lingua)

The mucous membrane over the dorsum, that is, the top surface of the tongue, is characterized by being extra rough and having large papilla scattered evenly throughout. The foramen cecum, the termination of the obliterated thyroglossal duct, is a small round pit at the midposterior top surface of the tongue. Extending forward and laterally from the foramen cecum on each side lie a series of larger papillæ, which are part of the localization of the special sense of taste. In the mucosa between these papillæ and the epiglottis lie a great number of solitary lymph nodules, known collectively as the lingual tonsil. The median and two lateral glossoepiglottidean musculoligamentous folds have been considered in connection with the larynx. The musculature of the tongue is of the voluntary type and is divided into an extrinsic and an intrinsic group. The extrinsic muscle, previously considered, are: the genioglossus, the hyoglossus, the styloglossus, and the glossopalatinus. The intrinsic muscles are collected into bands running from one part of the tongue to another in various planes and directions, and are not directly connected to bony origins. The main function of the tongue is an aid to mastication, but it has a subsidiary function in modifying the voice sounds, characteristically in the production of the linguals.

Dissection.—As the roof of the mouth forms the floor of the nose, it is advisable to postpone the completion of the mouth dissection until the nose has been considered. The student, however, can gain considerable knowledge of the anatomy of this region by examining his own mouth by palpation and by means of a looking glass, and by examining the mouth of a fellow-student. The tongue tends to rise up and to shut off a view of the isthmus of the fauces, but will tend to draw down if the individual pronounces a prolonged "Ah" or it may be mechanically depressed. The arches of the isthmus of the fauces are readily to be seen in any mouth, but the normal palatine tonsil of adult life is commonly so small as to be practically hidden between the arches. The extent of the hard palate should be made out by palpation. The soft palate and its uvular process should be noted to rise up when the individual pronounces "Ah." After the completion of the nose dissection, the palate and the isthmus of the fauces should be reviewed and dissected. The various muscles and nerves noted should be traced well into the substance of the tongue. Then the mandibular and hyoid bones should be sawed across in the anterior median line and the tongue should be completely divided by a midline incision.

The Nose (Nasus)

The nose is the normal passageway for air to and from the respiratory tract, but if both nasal cavities are blocked, the respiratory air may short-circuit through the mouth into the pharynx. The **nares**, or, popularly, nostrils, are the narrowest portions of the nasal cavities and as has been previously noted possess dilator muscles. The septum of the nose should theoretically be straight in the median line, but practically in the adult it commonly varies somewhat either to one side or the other. The nasal cavities are large narrow spaces, consequently the light entering through the nares does not reach the deeper portions of the interior. Examinations of the deeper parts are therefore made by reflected light, with a hole in the center of the mirror to get the examiner's eye in the middle of the light cone. The posterior apertures into the nasopharynx, which lie just about the posterior end of the hard palate, can be examined by light reflected from an angularly placed mirror held in back of the soft palate. The technical name for these apertures is choanæ, that is funnels.

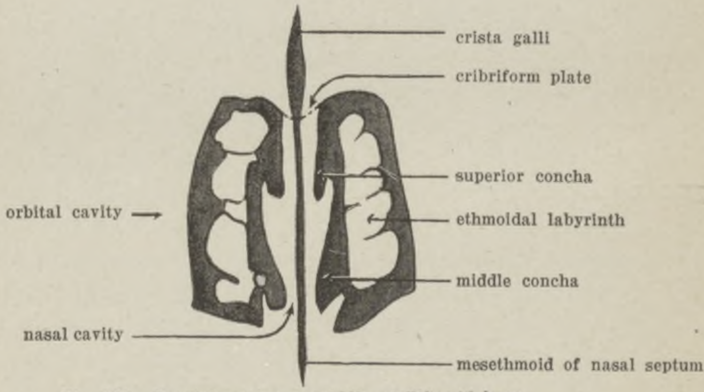


Fig. 100.—Frontal section at middle of **Ethmoid bone.**

Bony Boundaries

The front portion of the nose has a cartilaginous framework, while the rest of the walls of the nasal cavities are of bone. The septum is made up of the thin perpendicular plate of the ethmoid, with anteriorly a plate of cartilage and posteriorly a plate, which projects down from the body of the sphenoid, known as the **vomer** bone (vomer = ploughshare). The roof of the nasal cavities is made up of the cribriform plate of the ethmoid and the body of the sphenoid. The floor of the nasal cavities is made up of the palatal process of the maxilla and posteriorly the horizontal part of the palatal bone. The lateral wall is made up superiorly of the nasal bone, the frontal process of the maxilla, and the ethmoidal labyrinth, inferiorly of the maxilla, the perpendicular part of the palatal bone, and the medial pterygoid plate of the sphenoid. Along the lateral wall lie three curled porous bones known as the superior, middle, and inferior

nasal conchæ (O.T. turbinates) (concha = shell). The superior and middle conchæ are parts of the lateral masses of the ethmoid. The inferior nasal concha is a separate bone of larger size, which is attached by a suture line to the maxillary and palatal bones of the lateral nasal wall.

Lining of Nasal Cavities

The respiratory portions of the mucosa are lined by a columnar type of epithelium. The submucosa contains the larger arteries, veins, nerves, and lymphatics, which are held firmly in position by connective tissue. The submucosa is intimately attached to the mucosa and to the periosteal lining of the bony walls. In the mucosa of the conchæ lie large thin-walled blood sinuses, which functionate by moistening and heating the air in its passage through the nose. If the nose can not functionate for any reason at all, the inspired air should be well moistened and preferably near body temperature. If these conchal structures are not functionating properly, the remainder of the respiratory tract and mouth tends to become dry, parched, and inflamed.

A saw-cut should be carried through the roof and floor of the nose on one side of the septum in order to make a detailed examination of the interior of the nasal cavities. It should be especially noted that the nasal cavities are in reality much larger than most people without special information conceive them to be.

Air Sinuses

The three nasal conchæ covered by mucous membrane and containing the blood sinuses are readily to be made out along the lateral wall. By prying up the anterior portion of the inferior nasal concha the exit of the lacrymal duct into the nose may be noted, or a toothpick may be passed from the orbital part of the lacrymal duct down into the nasal cavity. The frontal bone is hollowed out under the supraorbital margin for a large air space of variable shape, which is lined by a mucoperiosteal layer. The body of the maxilla is likewise hollowed out for a big cavity, known as the air sinus of the maxilla, or, in the old terminology, as the antrum of Highmore. These air sinuses drain via ducts into the nose just under the middle nasal concha, this opening being technically known as the hiatus semilunaris. The ethmoidal labyrinth is hollowed out by air cells, that is a sinus which is partially subdivided by delicate bony partitions. The anterior ethmoidal cells empty into the frontal sinus duct, the posterior cells under the small superior concha. The sphenoidal air sinuses hollow out the body of the sphenoid and drain into the upper parts of the nasal cavities. These air sinuses are commonly so large that these facial bones are materially weaker than would be expected from an external examination.

Practical

Why those air sinuses exist and their probable function has never been definitely settled. The air spaces obviously do away with unnecessary weight and strength in the front part of the head. Presumably these spaces are less liable to cause serious trouble when connected with the nose than if not so connected, being more commonly infected, but on the other hand allowing readier drainage. Acute and the earlier stages of chronic nasal infections cause swelling of the nasal conchæ, which may partially block the exit of these air sinuses and the lacrymal duct into the nose. Infection then spreads into the air sinuses causing local tenderness, which tends to disappear with the subsidence of the nasal inflammation. Chronic air sinus infections call for surgical intervention in order to establish efficient dependent drainage. The operation indicated in a minor degree of this disease is commonly a cauterization of the inferior concha, while in the serious cases a partial resection of the middle concha is required. In the upright standing position of the body the air sinuses, with the exception of the maxillary and sphenoid have dependent drainage. A deviated septum, if markedly out of place, may interfere with the normal nasal drainage. Fractures of the nose or operations for partial resection of the septum have intrinsically a certain element of risk, inasmuch as the cribriform plate of the ethmoid may be broken, which accident commonly causes cerebrospinal meningitis.

The ducts of the air sinuses should be located, and then the sinuses should be opened up freely by breaking in the thin partitions between the sinuses and the nasal cavity.

Vessels and Nerves

The **internal maxillary** artery sends two large palatal branches downward through canals in the palatal bone. Branches of these vessels supply the lateral nasal wall including the conchal blood sinuses. The terminal part of these vessels continues straight through into the mucous membrane of the palate, supplying both the hard and soft palate regions. Another branch of the internal maxillary runs in a canal of the sphenoid bone across the roof of the nose and then courses diagonally downward and forward across the septum. A small continuation of this vessel goes through a midline foramen in the hard palate, supplying the anterior part of the hard palate. The veins and lymphatics, generally speaking, correspond to the arteries. The maxillary division of the trigeminal joins with branches of the sympathetic and other complicated nerves to form the sphenopalatine ganglion of Meckel, which lies about at the point where the internal maxillary artery enters the palatal bony canal. The ganglia sends out sympathetic processes which travel along with the arterial branches to the nose and to the palates. The olfactory nerves of the special sense of smell are distributed in the upper part of the nose, over both the medial and the lateral walls.

Nasopharynx (Pharynx, Pars Nasalis)

The nasopharynx is that portion of the pharynx lying above the elevated soft palate and below the base of the skull. Anteriorly it connects with the apertures of the nasal cavities (choanæ), while posteriorly lies the vertebral column. The lateral walls are made by the fibromuscular walls of the pharynx, the muscle falling considerably short of the base of the skull as no constriction action is normally required. The characteristic feature of the nasopharynx is the openings of the **auditory** or Eustachian **tubes** on the lateral wall at about the midpoint and just above the level of the hard palate (tuba auditiva, Eustachii). These air tubes connect up the nasopharynx with the middle ear, tending to equalize air pressure in the two cavities. The auditory tubes run straight backwards, upwards and lateralwards into the petrous portion of the temporal bones. The extrabony portion of this tube is held open by cartilaginous semirings, being widest at its pharyngeal end. The posterior wall of the pharynx has a large aggregation of lymphatic tissue in the mucosa, known as the **pharyngeal tonsil** (tonsilla pharangea).

The nasopharynx should be examined.

Elevator Palate Muscle

The two elevator muscles of the soft palate arise from the medial pterygoid plate of the sphenoid bone and run into the upper surface of the soft palate. The **tensor palatini** arises from the medial surface and runs directly downward to the soft palate. The **levator palatini** arises from the lateral surface and its tendon turns around a hook process at the bottom of the medial pterygoid plate en route to the soft palate. The medial pterygoid plate of the sphenoid is materially smaller than the lateral pterygoid plate, in conformity with the relative size of the palatine and pterygoid muscles.

These elevator, and the glossopalatinus and pharyngopalatinus depressor muscles of the soft palate should now be dissected.

Lymphatic Ring

The pharyngeal tonsil, the two palatine, or faucial tonsils, and the lingual tonsil make up what is known as the lymphatic ring of Waldeyer. The pharyngeal and lingual tonsils are normally low, irregular masses, and are not sharply defined from the more scattered lymphatic nodules of the neighboring areas. The palatine tonsils are normally almond-shaped, sharply circumscribed masses, which on their medial surfaces have a number of small pits (fossulæ) and on their lateral surfaces firm, white, fibrous capsules. The pharyngeal tonsil is connected essentially with the mucosa of the nose and nasopharynx, when chronically enlarged forming a soft, irregular mass known clinically as adenoids. Swelling of this tonsil characteristically interferes with breathing and may predispose to inflammations secondarily in the middle ear cavity. The palatine tonsils anatomically belong to the mucosa of the mouth and oropharynx, and when inflamed, tend to interfere with swallowing. Swelling and inflammation of the pharyngeal and palatine tonsils are very commonly associated, due to disease of the whole area or perhaps in part to a lymphatic anastomosis. The lymphatic tissue of this ring increases in amount in acute nasooropharyngeal infections and tends to remain hyperplastic in chronic disease.

Practical

The presence of solitary lymphatic nodules has previously been noted to be universal throughout all mucous membranes. Increase in the number of these nodules and eventually aggregations of nodules has been noted in those mucous membranes grossly more exposed to infection, as, for example, in the lower half of the small intestine, the appendix, and throughout the large intestine. The finding of aggregated masses of lymphatic nodules, in the naso-pharynx and throat, known as tonsils, is, therefore, not an unexpected feature, but is in accord with our previous anatomic experience. The tonsils are physiologically largest during childhood, and during adult life tend to progressively involute, that is, undergo retrograde changes.

The consensus of clinical opinion is that the function of the tonsils is unknown, which interpreted means that clinicians reject the argument that the tonsils are a protective defense organ and have no substitute hypothesis to offer. If the palatine tonsils are subject to recurring acute inflammations or to chronic infections with hyperplasia, the generally accepted opinion is that they together with their capsules should be completely removed. The older clinical evidence in regard to improvement following tonsillectomy was based on incomplete removals, whereas the modern clinical opinion concedes that the results of these operations were not fully satisfactory and demands that the tonsil removal should be absolutely complete. Irrespective of what is eventually accepted as the normal function of the palatine tonsils, the clinical evidence in regard to great improvement following partial or complete tonsillectomy in cases of hyperplastic tonsils is absolutely conclusive. That the greatly hyperplastic palatine tonsils go through a form of vicious circle, by which they no longer protect the individual, but definitely predispose to frequent and severe tonsillar attacks, seems to be proved beyond doubt by prolonged clinical experience. Some conscientious clinicians, while conceding the importance and value of tonsillectomy in properly selected cases, stoutly oppose what they consider extremists' views as regard both to indications and prognosis. They point out that historically in any new field only the strongest men are not carried to extremes by their enthusiasm; that clinically even the radical operation does not prevent fresh oro-pharyngeal infections, if the patient repeats previous errors of hygiene; and that in case of infection after the complete radical removal of the palatine tonsils, the danger of lymphatic enlargement and extrapharyngeal abscess may even be actually increased. In presenting this minority view, it is only fair to emphasize that the tendency of the specialists and even of the general practitioners is rather to widen than to restrict the indications for the operation of tonsillectomy.

Peritonsillar Abscess

The tonsils lie inside the submucosa of the pharynx, consequently when enlarged they follow the line of least resistance by bulging into the pharynx. The popular belief that swollen tonsils can be palpated from the outside is due to an accompanying swelling of the deep lymphatic glands of the neck. A peritonsillar abscess, or, popularly, quinzy, may be a diffuse inflammation or may be due to a breaking down of these lymphatic glands, which lie just outside of the submucosa. These abscesses in time tend to bulge into the pharynx, this being the line of lesser resistance. The common carotid arteries lie in very close relationship to the lateral walls of the laryngopharynx, while the internal and external carotids and the external maxillary arteries are commonly stated to be about three-quarters of an inch lateral to the oropharynx. Therefore, even when the abscess bulges well inwards, any unexpected movement of the patient's head during operative intervention with a sharp knife may cause a serious accident. The retropharyngeal abscesses, between the pharynx and the vertebral column, may be freely opened in the midline, practically without risk.

EAR

The ear, the special organ of hearing, is situated entirely within the temporal bone. The auricle or external ear is freely movable among the lower animals and in the human retains a slight range of motion as was noted in the consideration of the scalp. The function of the auricle is to gather sound waves from a large area, which are then transmitted to the drum membrane. The framework of the auricle is of yellow elastic fibrocartilage, which is covered by a fatty layer and skin. The lobule of the auricle is that portion which hangs down without a cartilaginous framework. The spiral curves leading down into the external acoustic meatus carry the concentrated sound waves to the drum.

External Acoustic Meatus (B.N.A. Acustic)

The external acoustic meatus is made up of a cartilaginous external half and a bony internal section. The canal runs, approximately speaking, straight inward, and is somewhat more than an inch in length by one-sixth of an inch in cross-section. The **tympanic membrane,** or, popularly, drum, shuts off the deep end of the external acoustic meatus from the middle ear cavity. The drum is not set in at a right angle, but on a distinctly downward-medialward and forward-medialward slant. On account of the depth and curving direction of the narrow canal, the tympanic membrane can only be examined satisfactorily by reflected light, with the auricle pulled backward in order to straighten out the canal. The tympanic membrane is made of white fibrous tissue, which on account of the darkness in the middle ear cavity appears as a steel-gray under the ordinary reflected light.

If pus accumulates in the middle ear cavity under pressure, the tympanic membrane is bulged lateralward and becomes injected, more especially at its upper segment. If a vacuum occurs in the middle ear cavity, the tympanic membrane is drawn medialwards and presses against the little bones of the middle ear. Hair and special waxy glands are protective structures of the external acoustic meatus. Foreign bodies or masses of dried wax in the canal would obviously interfere seriously with the transmission of sound waves.

The external acoustic meatus should be examined in the dissecting body and in a fellow-student's ear.

Middle Ear Cavity (Cavum Tympani)

The middle ear cavity or cavum tympani connects anteriorly through the auditory tube with the nasopharynx. The tympanic membrane forms the main part of the lateral wall of the middle ear cavity, being drawn somewhat medialward at its center. The medial wall has a **promontory** projecting lateralward, which is caused by the internal ear shell. A series of small bones with mutual articulation extend across from the tympanic membrane to the **fenestra vestibuli** just posterior to the promontory. These ossicles from without inward are the **malleus,** or hammer, the **incus,** or anvil, and the **stapes,** or stirrup. The handle of the malleus fits against the drum membrane, while the footpiece of the stirrup fits in the fenestra vestibuli. The ossicles are connected to each other and to the bony walls by ligaments, the malleus and incus in addition having special muscles controlled by branches from the facial nerve. This chain of ossicles serves to transmit the vibration of the tympanic membrane to the internal ear. The upper part of the middle ear cavity is known as the epitympanum, or attic, which is separated from the brain by only a thin though firm plate of bone, known as the paries tegmentalis. The epitympanum contains the heavier parts of the malleus and incus ossicles, and connects up posteriorly with the **mastoid air cells.**

If pus under pressure in the middle cavity is not promptly relieved by a free incision of the drum membrane, the tympanic cavity and the mastoid cells may become seriously infected. On account of the anatomic proximity and the various anastomoses, thrombosis of the transverse sinuses and secondary brain abscesses are not uncommon complications of middle ear and mastoid infections.

Dissection.—A horizontal saw-cut should be made through one temporal bone on a level with the upper margin of the internal acoustic meatus. A vertical saw-cut should be made through the other temporal bone, carrying the section through the posterior parts of the external and internal acoustic meatuses. The middle ear cavity should be located and carefully cleared of bone-dust. Then the tympanic membrane should be studied in both specimens. The ossicles should then be removed by grasping their heavier parts, which are located in the epitympanic portion of the middle ear cavity, and pulling them out. A small probe should then be passed through the nasopharyngeal orifice of the auditory tube into the middle ear cavity. The thin roof of the epitympanum and the bulging of the promontory should be especially noted.

Internal Ear (Auris Interna)

The internal ear bulges the medial wall of the middle ear cavity, forming the promontory. The internal ear contains, besides the essential organ of hearing, a series of canals which control equilibrium. Although anatomically associated, the **semicircular canals** have nothing whatever to do with hearing, the anatomic relationship being, as it were, accidental. Among the lower animals the equilibrium organ is anatomically separate from the organ of hearing. The combined hearing and equilibrium cavities are small, being about one-half inch anteroposteriorly by about one-quarter inch in other diameters. These structures are well protected against injury in the strong petrous portion of the temporal bone.

The combined hearing and equilibrium cavities are surrounded by a **bony labyrinth,** which is held firmly in the petrous portion of the temporal bone. Inside this bony labyrinth lies a membranous labyrinth, which is distended by an endo-fluid. The portion of the internal ear connecting the semicircular canals with the cochlea is known as the **vestibule.** The semicircular canals lie posteriorly to

Fig. 101.—**Internal Ear** (auris interna). (External view of right osseous labyrinth.)

the vestibule, and the three canals lie in the three planes of space. The cochlea is a spiral shell-like structure, which lies anteriorly to the vestibule and is the essential internal organ of hearing. The fenestra vestibuli lies just in back of the center of the promontory and receives impulses via the stirrup from the drum membrane (fenestra = window). The **fenestra cochlea** lies directly below the **fenestra vestibuli** and is considered to functionate as a safety valve against excessive vibration. The nerve cells of hearing arise in the cochlear membrane, and must carry their messages through the brain stem up to the temporal lobe of the cerebrum of the opposite side before sound can be interpreted (nervus cochlea). The peripheral nerves of hearing carry messages to the nuclei in the medulla oblongata portion of the brain stem, while the central nerves carry message to the temporal lobe of the cerebrum, chiefly of the opposite side. The nerve cells of equilibrium arise in the semicircular canal membrane and carry their messages into the cerebellum (nervus vestibuli). The internal ear is so well protected that it is but rarely disturbed by accident or infection.

The detail in regard to the internal ear can only be made out satisfactorily in decalcified temporal bones, with the aid of microscopic sections. The general size and position of the internal ear can be verified, however, by the removal of bone dust from the sectioned temporal bones.

Facial Nerve

The facial nerve enters the internal acoustic meatus in company with the acoustic nerve, but inside the temporal bone these nerves enter separate canals. The facial nerve runs horizontally lateralwards to the promontory, then turns straight backwards to the posterior wall of the tympanic cavity, which it follows vertically downwards to the stylomastoid foramen. The facial nerve has many complicated communicating branches with other nerves, its largest branch, the chorda tympani, going through a separate canal to join the lingual branch of the mandibular division of the trigeminal. Destruction of the facial nerve is always a possible complication of middle ear disease, more especially of operative interference.

The facial nerve should be traced in its course through the temporal bone.

Nerve and Blood Supply of Temporal Bone

No subject in anatomy is more complicated in its detail than the nerve supply of the temporal bone. The anatomy of the combined acoustic and equilibrium nerve is comparatively simple and established. The motor supply of the muscles within the temporal bone would be expected to come from the facial nerve, the sensory supply from the trigeminal nerve, whereas the involuntary supply should in theory come from the superior cervical ganglia. As a matter of fact the facial, the trigeminal, and the sympathetic nerves form a most complicated plexus, the various interconnecting strands of which traverse minute bony tunnels through the temporal bone. The number, position, and size of the connecting processes of this plexus have been definitely established, but the further course and significance of these strands is still an unsettled problem. The fact that some of the nerve processes belonging to the facial nerve ganglia of the brain stem short-circuit and travel along with the maxillary and mandibular divisions of the trigeminal, obviously complicates the solution. The various ganglia outside of the skull in connection with the plexus are generally considered to belong to the sympathetic nerves. The common reference of pain originating in the tympanic cavity along the various branches of the mandibular division of the trigeminal yields clinical evidence that the sensory supply of the middle ear is derived partly at any rate from that source. A sensory branch from the glossopharyngeal tunnels the bone and helps to supply the middle ear cavity.

Arterial branches from the middle meningeal, internal maxillary, and posterior auricular vessels supply the interior of the temporal bone. The veins, generally speaking, correspond to the arteries. The anastomoses between these veins and the cranial sinuses are a potential source of danger in middle ear infections.

INDEX*

* Both the older terminology (O. T.) and the Basle Nomina Anatomica (B. N. A.).

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